Review of particle properties

Particle Data Group

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This review of the properties of leptons, mesons, and baryons is an updating of Review of Particle Properties, Particle Data Group [Phys. Lett. **75B** (1978)]. Data are evaluated, listed, averaged, and summarized in tables. Numerous tables, figures, and formulae of interest to particle physicists are also included. A data booklet is available.

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I. INTRODUCTION, CREDITS, CONSULTANTS

This review is an updating through December 1979 of our previous review of particle properties [Particle Data Group (1978)]. As in previous editions we have attempted to make the text as complete and self-contained as possible.

As usual, the results of our compilation are presented in two sections, the Tables of Particle Properties and the Data Card Listings. The Tables summarize the properties of only those particles whose existence is in our judgment experimentally well founded and which have a large probability of standing the test of time. This is a conservative judgment, and surely some genuine resonances are omitted, awaiting confirmation (see section V below).

The Data Card Listings give up-to-date information, with references, on all reported particles, whether considered well established or not. The Listings also contain mini-reviews on questions of interest.

A history of the Particle Data Group, with a discussion of procedures and problems, has been given by Rosenfeld (1975) and a short survey of the history of some of the constants we compile can be found in Appendix IV.

We have maintained in this review the statistical procedure introduced in 1976, i.e., we give simultaneously in the Listings the old (labeled "AVG") and new (labeled "STUDENT") average values and errors. Details may be found in Sec. VII.

A pocket-sized Particle Properties Data Booklet, containing the Tables and a reprint of the figures and formulae from the first part of the review, is available on request. For North and South America, Australia, and the Far East, write to Technical Information Department, Lawrence Berkeley Laboratory, Berkeley, CA 94720, USA. For all other areas, write to CERN Scientific Information Service, CH-1211 Geneva 23, Switzerland.

As usual, we wish to emphasize that we compile the experimental results of others. It is inappropriate to give us the credit for their countless hours of effort. We urge that references be given directly to the original data, and we provide complete references in the Data Card Listings for that purpose.

The responsibilities for the various sections can be broken down as follows:

(1) *Stable particles*: N. Barash-Schmidt, C. P. Horne, M. J. Losty, T. Shimada, and T. G. Trippe.
(2) *Meson resonances*: C. Dionisi, M. J. Losty, M. Mazzucato, L. Montanet, and M. Roos.
(3) *Baryon resonances*: C. Bricman. R. L. Crawford, C. P. Horne, R. L. Kelly, M. J. Losty, and C. G. Wohl.
(4) *General, including text*: All authors.

Consultants: To overcome unavoidable gaps in our coverage, both intellectual and geographical, we have solicited the help of consultants:

- U. Amaldi (CERN),
- W. B. Atwood (SLAC),
- A. Barbaro-Galtieri (Lawrence Berkeley Laboratory),
- V. E. Barnes (Purdue University),
- R. Cahn (LBL),
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- R. G. Moorhouse (University of Glasgow),
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- S. I. Parker (Lawrence Berkeley Laboratory),
- M. Perl (SLAC),
- R. E. Shriock (SUNY Stony Brook),
- K. Shizaya (Lawrence Berkeley Laboratory),
- B. N. Taylor (U. S. National Bureau of Standards).

The usefulness of this compilation depends in large part on the interaction between the users and the authors and consultants. We appreciate comments, criticisms, and suggestions for improvements of all stages of data retrieval, processing, evaluation, and presentation.

II. SELECTION OF DATA

All particles are considered to fall into one of the three groups:

(1) Stable particles, immune to decay via the strong interaction, including the η and the photon and the leptons.
(2) Meson resonances.
(3) Baryon resonances.

The charmed, charmonium, and other new flavor particles have been merged into these groups.

These groups are maintained within the two main parts of the compilation:

(1) Tables of Particle Properties.
(2) Data Card Listings.

The Data Card Listings contain the original information (data, references, etc.), weighted averages, comments, and "mini-reviews". Immediately preceding the Data Card Listings is an illustrative key thereto. We attempt to give complete Data Card Listings up to our closing date (January 1, 1980) for all journals listed in the Illustrative Key. We also include preprints and unpublished conference reports that have come to our attention, but make no claim to completeness.

Roughly 40% of our encoded results, those set off in parentheses, are not used for averaging. The reasoning is then often given in a footnote below the data. If the reason is not given, it is one of the following:

- The result was presented with no error stated.
- The result comes from a preprint or conference report. It is our experience that such results (and

particularly the errors) often change before final publication. Accordingly we keep these new results in parentheses until they are published (or explicitly verified to us by the authors).

• It involves some assumptions that we do not wish to incorporate.

• It is of poor quality, e.g. bad signal-to-noise ratio.

• It is inconsistent with other results, e.g. because of different methods employed, rendering averaging meaningless.

• It is not independent of other results, e.g. it is a result from one of several partial-wave analyses all using the same data, again rendering averaging meaningless.

When the data for a particle have received special treatment or present special problems, this is noted in a mini-review in the Data Card Listings.

The Tables of Particle Properties represent the output of weighted averages and some critical judgment. The extent to which "blind" averaging has been tempered with judgment is explained in footnotes to the Tables. In general, however, the footnotes are less complete than is the collection of notes and mini-reviews in the Data Card Listings. The reader is thus encouraged to become familiar with the Data Card Listings and, ultimately, with the original references.

III. NOMENCLATURE

A. Quantum numbers

The symbols $I^G(J^P)C_n$ represent:

I = isospin,
G = G parity,
J = spin (also s),
P = space parity,
C_n = charge-conjugation parity for the neutral member of the isospin multiplet.

We also use:

B = baryon number,
S = strangeness,
C = charm,
l = orbital angular momentum.

1. Mesons

The charge-conjugation operator C turns particle into antiparticle and has eigenvalues ± 1 only for neutral states; so it is useful to define an operator G which has eigenvalues for charged states too. This is usually[1] defined by

$$G = C\exp(i\pi I_y). \tag{1}$$

A neutral nonstrange, noncharmed state is an eigenstate of $\exp(i\pi I_y)$ with eigenvalue $(-1)^I$. Then we can write the eigenvalue equation for the whole multiplet as

$$G = C_n(-1)^I, \tag{2}$$

where C_n (n for neutral) is the eigenvalue C would have if applied to the neutral member of the multiplet. Thus, for a π^0, C has the eigenvalue +1, and since $I=1$, $G=-1$. For a charged pion, there are no eigenvalues corresponding to C and to the isospin rotation, but Eqs. (1) and (2) still give $G=-1$.

Consider a meson as a bound state of fermion-antifermion, e.g. quark–antiquark $\bar{q}q$, with orbital angular momentum l, and with the two fermion spins coupling to give a spin s. Then one can show that the charge-conjugation eigenvalue [defined as in Eq. (2)] is

$$C_n = (-1)^{l+s}. \tag{3}$$

Eqs. (2) and (3) combine to give

$$G = (-1)^{l+s+I}. \tag{4}$$

The parity is

$$P = -(-1)^l. \tag{5}$$

Eqs. (3) and (5) combine to give

$$C_n P = -(-1)^s, \tag{6}$$

so all singlets ($^1S_0, {}^1P_1, \ldots$) have $C_nP=-1$, and all triplets ($^3S_1, \ldots$) have $C_nP=+1$. For proofs of the above, see our 1969 text [Particle Data Group (1969)] and Appendix by C. Zemach.

If, instead of $\bar{q}q$, we consider the meson as a state of *boson–antiboson* (e.g. $A_2 \to \bar{K}K$), it turns out that some signs cancel, and Eqs. (3) and (4) (not Eq. (5)!) apply *unchanged*. Of course, the mesons are often spinless, so s is zero, but the equations are more general. Eqs. (3) and (4) can be considered as selection rules forbidding many decays.

We now use Eqs. (3) and (4) to introduce the concept of "Abnormal-C_n" mesons, i.e. mesons that cannot be composed of $\bar{q}q$. For this, it is sufficient to consider the SU(3) subgroup of the full unitary group of flavors, containing the u, d, and s quarks in a $\{3\}$ representation.

This triplet of quarks is of course defined to have isospin and hypercharge properties such that $\bar{q}q$ can combine (according to the SU(3) relations $\{3\}\otimes\{3\} = \{8\}\oplus\{1\}$) so as to form only octets and singlets. The non-observation of "exotic" mesons (i.e., mesons in larger SU(3) representations, or mesons requiring at least a $q\bar{q}q\bar{q}$ structure) is of course a direct consequence of the naive quark model. States coupling directly to proton-antiproton channels are sometimes interpreted as "baryonium", requiring $q\bar{q}q\bar{q}$ structure, but this interpretation is model-dependent, and no manifestly exotic mesons have been found. It is slightly less obvious that even some *octets* are forbidden by the model, namely those with $(J^P)C_n = (0^\pm)-, (1^-)+, (2^+)-, \ldots$. Such states are not observed, and this is an additional success of the naive quark model classification scheme.

In what follows, do not confuse "Abnormal-C_n" with "Normal" or "Abnormal" J^P, both of which are allowed by the quark model. The series $J^P = 0^+, 1^-, 2^+, \ldots$ is called Normal because $P=(-1)^J$ as for normal spherical harmonics, and $J^P = 0^-, 1^+, \ldots$ is called Abnormal.

The top part of Table 1 shows all the low angular momentum states that can be formed from $\bar{q}q$. Note that half of the J^P states can be formed by both a triplet and a singlet $\bar{q}q$ state, e.g. $^3P_1$, $^1P_1$, *or* $^3D_2$, $^1D_2$.

[1] Most texts define it as in Eq. (1); see e.g. Gasiorowicz (1966); however, sometimes the rotation is taken about I_x. The difference between the two conventions is mentioned in a footnote in Källen (1964).

TABLE I. Orbital excitations of the $\bar{q}q$ system, and corresponding mesons. For the distinction between Abnormal J^P and Abnormal C_n, see text following Eq. (6) in Section III. Strange and charmed mesons share the same values of J^P as the $I=0$ and 1 states shown, but are not eigenstates of **G**. The second column, which gathers together $(J^P)_{N \text{ or } A} C_n P$, is a redundant intermediate step intended to make the table easier to read. The table repeats itself for each radial excitation.

Parity	$\bar{q}q$ State C_nP −	$\bar{q}q$ State C_nP +	(J^P) C_nP Normal or abnormal	$I^G(J^P)C_n$	Examples of ground state mesons: Non-strange, Non-charmed $S=C=0$	Strange $\lvert S\rvert=1$ $(I=\frac{1}{2})$	Charmed $\lvert C\rvert=1$ $(I=\frac{1}{2})$
			NORMAL-C_n STATES THAT CAN COME FROM $\bar{q}q$ MODEL				
Parity −	$^1S_0$		$(0^-)_A -$	$0^+(0^-)+$ $1^-(0^-)+$	η,η' π	K	D(1870)
Parity −		$^3S_1$	$(1^-)_N +$	$0^-(1^-)-$ $1^+(1^-)-$	$\omega,\phi,J/\psi(3100)$ ρ	$K^*(892)$	$D^*(2010)$
Parity +	$^1P_1$		$(1^+)_A -$	$0^-(1^+)-$ $1^+(1^+)-$	B		
Parity +		$^3P_0$	$(0^+)_N +$	$0^+(0^+)+$ $1^-(0^+)+$	$\varepsilon, S^*, \chi(3415)$ δ	κ	
Parity +		$^3P_1$	$(1^+)_A +$	$0^+(1^+)+$ $1^-(1^+)+$	D A_1	Q_1	
Parity +		$^3P_2$	$(2^+)_N +$	$0^+(2^+)+$ $1^-(2^+)+$	f, f' A_2	$K^*(1430)$	
Parity −	$^1D_2$		$(2^-)_A -$	$0^+(2^-)+$ $1^-(2^-)+$	A_3		
Parity −		$^3D_1$	$(1^-)_N +$	same as $^3S_1$	$\psi(3770)$		
Parity −		$^3D_2$	$(2^-)_A +$	$0^-(2^-)-$ $1^+(2^-)-$	Regge recurrence of the Abnormal-C_n state $(J^P)C_n = (0^-)-$		
Parity −		$^3D_3$	$(3^-)_N +$	$0^-(3^-)-$ $1^+(3^-)-$	$\omega(1670)$ g	$K^*(1780)$	
Parity +	$^1F_3$		$(3^+)_A -$	$0^-(3^+)-$ $1^+(3^+)-$			
Parity +		$^3F_2$	$(2^+)_N +$	same as $^3P_2$			
Parity +		$^3F_3$	$(3^+)_A +$	$0^+(3^+)+$ $1^-(3^+)+$			
Parity +		$^3F_4$	$(4^+)_N +$	$0^+(4^+)+$ $1^-(4^+)+$	h		
			ABNORMAL-C_n STATES THAT CANNOT COME FROM $\bar{q}q$ MODEL				
	Abnormal C_n states Have no $\bar{q}q$ model		$(0^-)_A +$	$0^-(0^-)-$ $1^+(0^-)-$	All except $J^P = 0^-$ are J^P = normal, $C_nP = -1$		
			$(1^-)_N -$	$0^+(1^-)+$ $1^-(1^-)+$			
			$(0^+)_N -$	$0^-(0^+)-$ $1^+(0^+)-$			
			$(2^+)_N -$	$0^-(2^+)-$ $1^+(2^+)-$			
			$(3^-)_N -$	$0^+(3^-)+$ $1^-(3^-)+$			

Equation (3) shows that $^3P_1$ and $^1P_1$ have opposite C_n, so the $\bar{q}q$ model allows both. But the states $^3P_0$ and $^3P_2$ have no ^1P counterparts. According to Eq. (6) they have $C_nP=+1$, and with the $\bar{q}q$ model there is no way to form a state with a J^P of $^3P_{0,2}$ (i.e. J^P = Normal) and with $C_nP=-1$. As mentioned, such octets have not shown up. With the help of Table I one can also see that the special state $^1S_0$, $C_nP=+1$, cannot be formed, so has Abnormal C_n.

When, in addition to the l-excitation, there are radial excitations of the $\bar{q}q$ system, Table I repeats itself, and we need a radial quantum number n for each repetition ($n=1$ for the ground state). Examples of first radial excitations, $n=2$, are $\rho'(1600)$, $\psi(3685)$, and $\Upsilon'(10060)$. Examples of further possible radial excitations can be found in the ψ and Υ families.

2. General remarks

Well-established quantum numbers are underlined in the Tables of Particle Properties (except for stable particles, where most of the quantum numbers are established). We have used what evidence is available (sometimes flimsy) to guess many of the remaining ones, and we have indicated with "?" ones (in the Baryon Table) for which there is almost no evidence.

As is customary, we define antiparticles as the result of operating with CPT on particles, so both share the same spins, masses, and mean lives. Whenever there is a particularly interesting test of CPT invariance we include it in the Stable Particles Table.

B. Particle names

If a *meson* has a well-accepted colloquial name, we use it. If not, we name it by a single symbol which specifies its baryon number B (=0 for mesons), its isospin I, its strangeness S and charm C, and, for a non-strange, non-charmed meson, its G parity.

The name conventions for mesons are given in the first part of Table II.

TABLE II. Particle name conventions.

Name	I	S	C	G
Mesons				
η	0	0	0	+
$\omega, \phi, \psi, T^{a}$	0	0	0	−
ρ	1	0	0	+
π	1	0	0	−
K	1/2	±1	0	
D	1/2	0	±1	
F	0	±1	±1	
Baryons				
N	1/2	0	0	
Δ	3/2	0	0	
Z_0, Z_1	0, 1	+1	0	
Λ	0	−1	0	
Σ	1	−1	0	
Ξ	1/2	−2	0	
Ω	0	−3	0	
Λ_c	0	0	1	
Σ_c	1	0	1	

[a] We use the symbol ω for those $I^G=0^-$ mesons which are mainly $u\bar{u}$ and $d\bar{d}$ quark states; ϕ for those which are mainly $s\bar{s}$ quark states, ψ for mainly $c\bar{c}$ states, and T for mainly $b\bar{b}$ (hypothesized) states.

For *some* pairs of *mesons* with supposedly identical quantum numbers, we also use primes; e.g. $\eta, \eta'; f, f'$; ρ, ρ'. Note that primes and subscripts do not carry any further specific meaning.

For *baryons* no attempt has been made to attach a subscript about J and P. The name conventions are given in the second part of Table II. For stable baryons of each I and S we use the symbol standing alone; for resonances, the mass is in parentheses [i.e. $N(1688)$, $\Lambda(1405)$, $\Sigma(1765)$, etc.]. The J^P assignments are reported in the Baryon Table as $\frac{1}{2}+$, $\frac{3}{2}-$, $\frac{5}{2}+$, etc., and also by the symbols P_{11}, D_{13}, F_{15}, which refer to the πp or Kp partial-wave amplitude in which the resonant state occurs (the first subscript refers to the isospin state: $2\times I$ for N and Δ and just I for Z, Λ, and Σ). When two or more baryons have identical quantum numbers we warn the reader by adding primes to the spectroscopic symbol as explained in footnote (a) of the Baryon Table.

IV. CONVENTIONS AND PARAMETERS FOR STRONG INTERACTIONS

A. Partial-wave amplitudes and resonance parameters

The vast majority of information concerning baryon resonances comes in the form of partial-wave analyses. In addition data concerning meson resonances ($\pi\pi$, $K\pi$, $\pi\pi\pi$) are, with increasing frequency, being subjected to partial-wave analyses. We thus find it natural to introduce the resonance parameters which we compile in terms of a Breit–Wigner approximation for the partial-wave amplitude.

In general the elastic amplitude for a given angular momentum l may be written as

$$T_{11}=\frac{\eta\exp(2i\delta)-1}{2i}, \qquad (1)$$

where η is the absorption parameter $(0\leq\eta\leq1)$ and δ is the phase shift. The subscripts 11 on T denote scattering from channel 1 to channel 1 (e.g. $\pi\pi\to\pi\pi$ or $\bar{K}K\to\bar{K}K$).

In Fig. 1 we show an Argand plot of the elastic partial wave amplitude T_{11}. It illustrates geometrically how the real parameters η and δ are related to the real and imaginary parts of T_{11}. Many examples of such Argand plots may be found in the Baryon Data Card Listings.

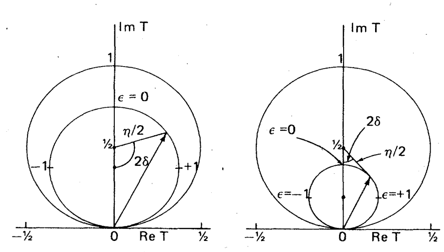

FIG. 1. Argand plots for the elastic partial wave amplitude T_{11}. The outer circles are the unitarity bound ($\eta=1$). The inner circles correspond to the Breit–Wigner approximation of Eq. (2) for (a) $x_1=\Gamma_1/\Gamma=0.75$ and (b) $x_1=0.4$. Note: $\epsilon=/2(M-E)/\Gamma$.

Consider the so-called non-relativistic Breit–Wigner approximation for T_{11}:

$$T_{11}=\tfrac{1}{2}\Gamma_1/(M-E-\tfrac{1}{2}i\Gamma)\,, \tag{2}$$

where E is the c.m. energy or invariant mass, Γ_1 and Γ are the *elastic* and *total* widths, and M is the *resonance mass*. Equation (2) is, of course, not the only possible description of a resonant amplitude; but it suffices to illustrate the properties of partial-wave amplitudes which we associate with resonance behavior in the absence of any background in the same partial wave (see, e.g., the πN D_{15} and F_{15} waves in the Baryon Data Card Listings). Usually the widths contain barrier-penetration factors which can vary rapidly with energy. Near threshold, $\Gamma_1(E)$ should start up as q^{2l+1} (also true for the inelastic width Γ_β). Various E dependences are then used for Γ_1, mostly of the form

$$\Gamma_1(E)\propto\frac{(qR)^{2l+1}}{\text{const}+\ldots+(qR)^{2l}}\,; \tag{3}$$

see Jackson (1964), Pišút and Roos (1968), and Barbaro-Galtieri (1968).

The BW approximation to the amplitude for an inelastic process leading from channel 1 to channel β ($\pi\pi\to\bar{K}K$ or $\bar{K}N\to\Sigma\pi$, for example) is

$$\begin{aligned}T_{1\beta}&=\tfrac{1}{2}(\Gamma_1\Gamma_\beta)^{1/2}/(M-E-\tfrac{1}{2}i\Gamma)\\&=(x_1x_\beta)^{1/2}[\tfrac{1}{2}\Gamma/(M-E-\tfrac{1}{2}i\Gamma)]\,,\end{aligned} \tag{4}$$

where

$$\Gamma=\sum_1^N\Gamma_\beta,\quad x_\beta=\Gamma_\beta/\Gamma\,, \tag{5}$$

and x_1 (called the elasticity) is often written x_e. (Note that in the Data Card Listings we use the symbol P_β to denote x_β.) The channel cross section $\sigma_{1\beta}$ for the reaction $1\to\beta$, for spin 0–spin 1/2 scattering, is

$$\sigma_{1\beta}=4\pi\lambda\!\!\!^{-2}(J+\tfrac{1}{2})\,|T_{1\beta}|^2\,, \tag{6}$$

where $J=l\pm\frac{1}{2}$.

The important features of Eq. (4) which characterize resonant behavior in the Argand diagram (Im $T_{1\beta}$ versus Re $T_{1\beta}$) are:

energy variation given by circles with diameter $(x_1x_\beta)^{1/2}$ and maximum amplitude at $E=M$ of

$$T_{1\beta}^{\max}=i(x_1x_\beta)^{1/2}\,; \tag{7}$$

a maximum in the speed near resonance, given approximately by

$$\text{“Speed” (res)}=|dT_{1\beta}/dE\,|_{E=M}=\frac{2(x_1x_\beta)^{1/2}}{\Gamma(E)}\,, \tag{8}$$

for slowly varying $\Gamma(E)$. These features may be related to the η,δ representation of T_{11}. Thus when $E=M$, δ is either 90° ($x_1>\frac{1}{2}$) or 0° ($x_1<\frac{1}{2}$) and η dips to its minimum value.

These simple properties can be used to judge the presence or absence of resonance behavior in an Argand plot, but do not necessarily constitute the criteria we use (see Sec. V). It must also be kept in mind that Eqs. (2) and (4) are only approximations to the "true" amplitude. The simple picture given above can be distorted by various effects:

the presence of "background" in the same partial wave as the resonance,

two resonances in the same partial wave overlapping in energy,

the resonant energy M being close to an inelastic channel threshold, in which case a K-matrix-like parametrization is more appropriate,

the speed of the resonance being very slow so that the resonance is very broad, and the Breit–Wigner formula a bad approximation.

B. Sign conventions for resonance couplings

Consider the partial width Γ_β of a resonance decaying into the channel β. We can always define a coupling constant such that

$$\Gamma_\beta\propto G_\beta^2\,.$$

In this case the inelastic amplitude in the Breit–Wigner approximation, Eq. (4), will go as

$$T_{1\beta}\propto G_1G_\beta/(M-E-\tfrac{1}{2}i\Gamma)\,,$$

where G_1 is the coupling constant for the elastic channel. In the context of exact SU(3) symmetry the relative signs of the product G_1G_β for different resonances are often useful as a consistency check on SU(3) assignment of baryon resonances. See Appendix II for further details.

In the Data Card Listings for baryon resonances, we tabulate measured values for $(x_1x_\beta)^{1/2}\propto G_1G_\beta$. When the sign of the amplitude is determined, it is given; absence of an explicit sign indicates that it is undetermined (*not* that it is positive). For Λ and Σ resonances, the signs are chosen according to the convention advocated by Levi-Setti (1969) and used in the table of SU(3) Isoscalar Factors presented in this review. Thus the signs multiplying the Breit–Wigner amplitudes for $\bar{K}N\to\Sigma(1385)\to\Sigma\pi$, $\Lambda\pi$ and $\bar{K}N\to\Lambda(1405)\to\Sigma\pi$ are simply the product of the phases of the appropriate isoscalar factors. This convention is shown in Fig. 2, adapted from Levi-Setti (1969).

C. Types of partial-wave analyses

Partial-wave analyses (PWA) are classified into three categories in the Data Card Listings: energy-independent partial-wave analyses (IPWA), energy-dependent partial-wave analyses (DPWA), and model-dependent partial-wave analyses (MPWA), in increasing order of the number of explicit supplementary hypotheses that are used to extract the amplitudes from experimental data.

In an IPWA, data at different energies are analyzed separately. Usually each partial wave included in the fit is allowed to vary freely (subject to unitarity constraints) over some large region, and waves whose angular momenta are above some cutoff value are assumed to be negligible. The sharp cutoff in angular momentum resolves continuum ambiguities in the solution (such as the overall phase ambiguity), but there remains a finite number of indistinguishable "best" solutions (i.e., solutions corresponding to identical physical observables) which have been codified by Barrelet (1972). In addition, there are generally some

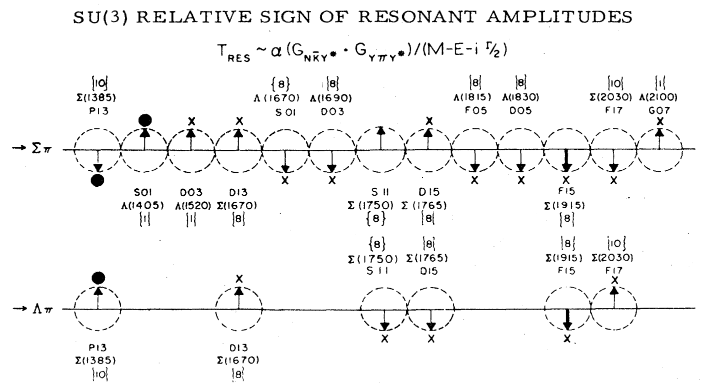

FIG. 2. Plot adapted from Levi-Setti (1969) showing the sign convention adopted here for the $\Sigma\pi$ and $\Lambda\pi$ amplitudes. Once the signs of one $I=0$ and one $I=1$ amplitude are fixed, the others can be measured relative to these two. Arrows here indicate signs predicted by SU(3); × marks indicate the observed phases; ● indicates phase chosen according to sign convention described in text. The $\Sigma(1915)$ predictions have been changed from Levi-Setti's original figure.

nearby solutions (and their associated Barrelet ambiguities) which have chi-squared values close to the minimum one.

At the end of the analysis a choice is made among these many solutions, usually on the basis of energy continuity. A popular criterion for making this choice is the shortest path technique in which the total "length" of the preferred solution is chosen to be a minimum. The definition of "length" used here is not universal but is usually closely related to the total geometrical length of the lines representing the various partial-wave amplitudes in Argand plots (see the baryon section of the Data Card Listings for examples of Argand plots). Various other criteria which are also used in some analyses are, e.g., matching with known solutions at low energies, the presence of known resonances in the final results, and limited inelasticity in high partial waves.

In a DPWA, data at different energies are fit simultaneously by using an energy dependent parametrization of the partial-wave amplitudes. The parametrization is usually chosen to include both resonances and nonresonant background of some sort and an attempt is made to keep it as "model independent" as possible. Often the data are grouped into several energy bins which are fit separately rather than trying to fit the whole energy range under consideration simultaneously. One of the main advantages of DPWA over IPWA is that sparse data spread over many different energies can be analyzed, e.g., nearly all $S=-1$ analyses are DPWA. In addition, the built-in energy continuity helps to resolve the ambiguities that plague IPWA and eases the problems associated with resonance parameter extraction. The price one pays for these advantages lies in the danger of systematic error in the amplitudes and poor fits to the data if the parametrization is poorly chosen or insufficiently flexible.

An MPWA also uses an energy-dependent parametrization, but one based on explicit model-dependent theoretical assumptions such as Regge exchanges. This technique is usually applied to reactions where the data are incomplete. There is, of course, no sharp distinction between DPWA and MPWA, and a well chosen MPWA parametrization may actually be less biased than a model-independent but poorly chosen DPWA parametrization.

D. Production of resonances

Hereby, we mean the observation of statistically significant peaks in invariant mass plots or, loosely, in integrated cross sections. Many meson resonances are of this type. We expect most of these peaks to be associated with Breit–Wigner behavior in appropriate Argand plots; thus the ρ meson peak in $\pi\pi$ mass plots is firmly related to the $I=1$, $l=1$ $\pi\pi$ phase shift passing through 90°.

From mass plots we can determine M, Γ, and the approximate branching ratios

$$x_\alpha/x_\beta=\Gamma_\alpha/\Gamma_\beta\,. \tag{9}$$

In the case of total cross sections, the peak above background gives us, using the optical theorem, the product $(J+\frac{1}{2})x_e$:

$$\sigma^{\rm tot}(E=M)=4\pi\lambda\!\!\!^{-2}(J+\tfrac{1}{2})x_e\,. \tag{10}$$

V. CRITERIA FOR RESONANCES

An experimentalist who sees indications of a resonance in some energy (or mass) region will of course want to know what has been seen in that region in the past; hence, we strive to have the Data Card Listings serve as an archive for all substantial claims for resonances.

For the Tables of Particle Properties, on the other hand, we wish to be more conservative and to include only those peaks or resonances which we feel have a large chance of survival. An arrow (→) at the left of the Tables of Particle Properties indicates that a questionable candidate has been omitted from the Table, but that it can be found in the corresponding part of the Data Card Listings. One's betting odds for survival are of course subjective; therefore no precise criteria can be defined. Very slow speeds (ε and κ) make it quite difficult to decide what is a resonance and what is not. For more detailed discussions, see the mini-reviews in the Listings. In what follows we shall attempt to specify some guidelines.

(a) When energy-independent partial-wave analyses are available (mostly for N^*'s), approximate Breit–Wigner behavior of the amplitude appears to us to be the most satisfactory test for a resonance. We can check that the Argand plot follows roughly a lefthand circle, and that the "speed" of the amplitude also shows a maximum near the resonance energy; further, there should be data well above the resonance, showing that the speed again decreases. Indeed proper behavior of the partial-wave amplitude could accredit a resonance even if its elasticity is too small to make a noticeable peak in the cross section.

Of course even if Argand plots are available, it may still be a matter of opinion as to what behavior constitutes a resonance. Such an example is the $Z_0(1780)$ state seen in KN total cross-section experiments and in partial-wave analysis. The partial-wave analyses of Giacomelli (1974) and Martin (1975) find preferred solutions which exhibit a resonance-like loop in the P_{01} wave near 1740 MeV. However, Giacomelli *et al.* and Martin point out that, despite the resonantlike *appearance* of the loop, the evidence for resonant *energy dependence* is inconclusive. Thus we omit the $Z_0(1780)$ from the Baryon Table. A similar quandary has existed for some time concerning the $Z_1(1900)$, and it too has been omitted from the Tables.

(b) When there are insufficient data to perform energy-independent analyses, one often resorts to energy-dependent partial-wave analyses (mostly for Y^*'s). In this case Breit–Wigner behavior is an input. We therefore require that resonance solutions be found by several different analyses, preferably in different channels ($\overline{K}N \to \overline{K}N$, $\pi\Sigma$, etc.), before putting the claim in the table.

(c) Partial-wave analyses of three-body final states ($\pi N \to \pi\pi N$) are now available. While these analyses are based on the isobar model ($\pi N \to \rho N$, $\pi\Delta$, etc.) and are subject to theoretical objections of varying importance, they provide increasingly reliable information on inelastic decay modes of otherwise established resonances.

(d) Most mesons, Ξ^* peaks, and high mass N^* and Y^* peaks fall into a category for which no partial-wave analyses exist. In general we accept such peaks if they are experimentally reliable, of high statistical significance or observed in several different production processes.

Thus, we enter into the Tables of Particle Properties only states for which there is experimentally convincing evidence, and we expect that most of these will be confirmed as resonances.

VI. CONVENTIONS AND PARAMETERS FOR WEAK AND ELECTROMAGNETIC DECAYS

A. Muon-decay parameters

The μ-decay parameters describe the momentum spectrum (ρ and η), the asymmetry (ξ and δ), and the helicity (h) of the electron in the process $\mu^{\pm} \to e^{\pm} + \nu + \overline{\nu}$. Assuming a local and lepton-conserving interaction, the matrix element may be written as

$$\sum_i \langle \overline{e} | \Gamma_i | \mu \rangle \langle \overline{\nu} | \Gamma_i (C_i + C_i' \gamma_5) | \nu \rangle ,$$

where the summation is taken over $i = S, V, T, A, P$. Using the definitions and sign conventions of Kinoshita and Sirlin (1957), we have for the momentum parameters

$$\rho = [3g_A^2 + 3g_V^2 + 6g_T^2]/D ,$$

$$\eta = [g_S^2 - g_P^2 + 2g_A^2 - 2g_V^2]/D ,$$

for the asymmetry parameters:

$$\xi = \frac{6g_S g_P \cos\phi_{\rm SP} - 8g_A g_V \cos\phi_{\rm AV} + 14 g_T^2 \cos\phi_{TT}}{D} ,$$

$$\delta = [-6g_A g_V \cos\phi_{\rm AV} + 6g_T^2 \cos\phi_{TT}]/D\xi ,$$

and for the parameter describing the helicity of the electron:

$$h = \frac{2g_S g_P \cos\phi_{\rm SP} - 8g_A g_V \cos\phi_{\rm AV} - 6g_T^2 \cos\phi_{TT}}{D} .$$

Here

$$D = g_S^2 + g_P^2 + 4g_V^2 + 6g_T^2 + 4g_A^2 ,$$

$$g_i^2 = |C_i|^2 + |C_i'|^2 ,$$

and

$$\cos\phi_{ij} = {\rm Re}(C_i^* C_j' + C_i' C_j^*) .$$

The quantities g_i are defined to be real non-negative numbers, and the ϕ_{ij} are phase angles between the i-type and j-type interactions. Under the assumption of two-component neutrinos $C_i' = -C_i$ and $C_j' = -C_j$, the S, P, and T terms vanish, and $\phi_{\rm AV}$ is the phase angle between C_A and C_V in the complex plane.

By using the above equations and the experimental determinations of ρ, η, ξ, δ, and h, limits can be placed on g_S/g_V, g_A/g_V, g_T/g_V, g_P/g_V, and $\phi_{\rm AV}$. The results, given in the Data Card Listings, assume neither two-component neutrinos nor time-reversal invariance. If, however, two-component neutrinos are assumed, then $\sin\phi_{\rm AV}$ is the amplitude of time-reversal violation. Note that most experiments study only the upper end of the spectrum where ρ and η are highly correlated, so they can only report ρ for $\eta \equiv 0$ and η for $\rho \equiv \frac{3}{4}$. The values for ρ and η we use here were obtained by combining measurements of both upper and lower ends of the spectrum and turn out to be nearly uncorrelated.

Note also that the radiative corrections are unambiguous only when $g_S = g_T = g_P = 0$. The same limits on g_A/g_V and $\phi_{\rm AV}$ are obtained, however, as when g_S, g_T, and g_P are left free.

Current values for the asymmetry parameters as well as $|g_A/g_V|$ and $\phi_{\rm AV}$ are given in the Addendum to the Stable Particle Table. In addition, upper limits on $|g_S/g_V|$, $|g_T/g_V|$ and $|g_P/g_V|$ are given in the μ section of the Stable Particle Data Card Listings.

B. K-decay parameters

1. Dalitz plot for $K \to 3\pi$ decays

The Dalitz plot distribution for the τ mode ($K^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}$), the τ' mode ($K^{\pm} \to \pi^0\pi^0\pi^{\pm}$), and the τ^0 mode ($K_L^0 \to \pi^+\pi^-\pi^0$) of K decay can be parametrized by a series expansion such as that introduced by Weinberg (1960). We use the form

$$|M|^2 \propto 1 + g\frac{s_3 - s_0}{m_{\pi^+}^2} + h\left(\frac{s_3 - s_0}{m_{\pi^+}^2}\right)^2 + j\frac{s_2 - s_1}{m_{\pi^+}^2} + k\left(\frac{s_2 - s_1}{m_{\pi^+}^2}\right)^2 + \ldots , \quad (1)$$

where $m^2_{\pi^+}$ has been introduced so as to make the coefficients g, h, j, and k dimensionless, and

$$s_i = (P_K - P_i)^2 = (m_K - m_i)^2 - 2m_K T_i, \quad i = 1, 2, 3,$$

$$s_0 = \tfrac{1}{3}\sum_i s_i = \tfrac{1}{3}(m_K^2 + m_1^2 + m_2^2 + m_3^2).$$

Here the P_i are 4-vectors, m_i and T_i are the mass and kinetic energy of the ith pion, and the index 3 is used for the odd pion.

The coefficient g is a measure of the slope in the variable s_3 (or T_3) of the Dalitz plot, while h and k measure the quadratic dependence on s_3 and $(s_2 - s_1)$, respectively. The coefficient j is related to the asymmetry of the plot and must be zero if CP invariance holds (C stands for charge conjugation throughout the discussion in this section). Note also that if CP is good, g must be the same for τ^+ and τ^-, and similarly for h and k.

Since different experiments use different forms for $|M|^2$, in order to compare the experiments we have converted to g, h, j, and k whatever coefficients have been measured. See the mini-review in the $K^\pm$ section of the Stable Particle Data Card Listings for details on this point. The results are given in the Addendum to the Stable Particle Table and in the $K^\pm$ and K_L^0 sections of the Stable Particle Data Card Listings.

Relations among $\tau^\pm$, $\tau'^\pm$, and τ^0 are predicted by the $\Delta I = \frac{1}{2}$ rule. See Appendix I for these relations and a discussion of this rule.

2. Form factors in $K_{\ell 3}$ leptonic decays

Assuming that only the vector current contributes to these decays, we write the matrix element as

$$M \propto f_+(t)[(P_K + P_\pi)_\mu \bar{u}_l \gamma_\mu (1+\gamma_5)u_\nu] + f_-(t)[m_l \bar{u}_l (1+\gamma_5)u_\nu], \tag{2}$$

where P_K and P_π are the four momenta of K and π mesons; m_l is the lepton mass; f_+ and f_- are dimensionless form factors which can depend only on $t = (P_K - P_\pi)^2$, the square of the four-momentum transfer to the leptons. f_+ and f_- are relatively real if time-reversal invariance holds for these decays. $K_{\mu 3}$ experiments measure f_+ and f_-, while K_{e3} experiments are sensitive only to f_+ because the presence of the lepton mass makes the f_- term negligible.

(*a*) $K_{\mu 3}$ *experiments*.

Analyses of $K_{\mu 3}$ data frequently assume a linear dependence of f_+ and f_- on t, i.e.

$$f_\pm(t) = f_\pm(0)[1 + \lambda_\pm(t/m_\pi^2)]. \tag{3}$$

Most $K_{\mu 3}$ data are adequately described by Eq. (3) for f_+ and a constant f_- (i.e. $\lambda_- = 0$). There are two equivalent parametrizations commonly used in these analyses:

(1) λ_+, $\xi(0)$ *parametrization*. Analyses of $K_{\mu 3}$ data often introduce the ratio of the two form factors

$$\xi(t) = f_-(t)/f_+(t).$$

The $K_{\mu 3}$ decay distribution is then described by the two parameters λ_+ and $\xi(0)$ (assuming time reversal invariance and $\lambda_- = 0$). These parameters can be determined by three different methods:

Method A. By studying the Dalitz plot or the pion spectrum of $K_{\mu 3}$ decay. The Dalitz plot density is [see, e.g. Chounet *et al.* (1972)]:

$$\rho[E_\pi, E_\mu) \propto f_+^2(t)[A + B\xi(t) + C\xi(t)^2],$$

where

$$A = m_K(2E_\mu E_\nu - m_K E'_\pi) + m_\mu^2(\tfrac{1}{4}E'_\pi - E_\nu),$$

$$B = m_\mu^2(E_\nu - \tfrac{1}{2}E'_\pi),$$

$$C = \tfrac{1}{4}m_\mu^2 E'_\pi,$$

$$E'_\pi = E_\pi^{\max} - E_\pi = \frac{m_K^2 + m_\pi^2 - m_\mu^2}{2m_K} - E_\pi.$$

Here E_π, E_μ, and E_ν are respectively the pion, muon, and neutrino energies in the kaon center of mass. The density ρ is fit to the data to determine the values of λ_+, $\xi(0)$, and their correlation.

Method B. By measuring the $K_{\mu 3}/K_{e3}$ branching ratio and comparing it with the theoretical ratio [see, e.g., Fearing *et al.* (1970)] as given in terms of λ_+ and $\xi(0)$, assuming μ-e universality:

$$\Gamma(K_{\mu 3}^\pm)/\Gamma(K_{e3}^\pm) = 0.6457 + 1.4115\lambda_+ + 0.1264\xi(0) + 0.0192\xi(0)^2 + 0.0080\lambda_+\xi(0),$$

$$\Gamma(K_{\mu 3}^0)/\Gamma(K_{e3}^0) = 0.6452 + 1.3162\lambda_+ + 0.1246\xi(0) + 0.0186\xi(0)^2 + 0.0064\lambda_+\xi(0).$$

This cannot determine λ_+ and $\xi(0)$ simultaneously but simply fixes a relationship between them.

Method C. By measuring the muon polarization in $K_{\mu 3}$ decay. In the rest frame of the K, the μ is expected to be polarized in the direction $\mathbf{A}$ with $\mathbf{P} = \mathbf{A}/|\mathbf{A}|$, where $\mathbf{A}$ is given [Cabibbo and Maksymowicz (1964)] by

$$\mathbf{A} = a_1(\xi)\mathbf{p}_\mu - a_2(\xi)\left\{\frac{\mathbf{p}_\mu}{m_\mu}\left[m_K - E_\pi + \frac{\mathbf{p}_\pi \cdot \mathbf{p}_\mu}{|\mathbf{p}_\mu|^2}(E_\mu - m_\mu)\right] + \mathbf{p}_\pi\right\} + m_K \operatorname{Im}\xi(t)(\mathbf{p}_\pi \times \mathbf{p}_\mu).$$

If time-reversal invariance holds, ξ is real, and thus there is no polarization perpendicular to the K-decay plane. Polarization experiments measure the weighted average of $\xi(t)$ over the t range of the experiment, where the weighting accounts for the variation with t of the sensitivity to $\xi(t)$.

(2) λ_+, λ_0 *parametrization*. Some of the more recent $K_{\mu 3}$ analyses have parametrized in terms of the form factors f_+ and f_0 which are associated with vector and scalar exchange respectively to the lepton pair. f_0 is related to f_+ and f_- by

$$f_0(t) = f_+(t) + [t/(m_K^2 - m_\pi^2)]f_-(t).$$

Here $f_0(0)$ must equal $f_+(0)$ unless $f_-(t)$ diverges at $t = 0$. The earlier assumption that f_+ is linear in t and f_- is constant leads to f_0 linear in t:

$$f_0(t) = f_0(0)[1 + \lambda_0(t/m_\pi^2)].$$

With the assumption that $f_0(0) = f_+(0)$, the two parametrizations, $(\lambda_+, \xi(0))$ and (λ_+, λ_0) are equivalent as long as correlation information is retained. (λ_+, λ_0) correlations tend to be less strong than $(\lambda_+, \xi(0))$ correlations.

The experimental results for $\xi(0)$ and its correlation with λ_+ are listed in the $K^\pm$ and K_L^0 sections of the Stable Particle Data Card Listings in Sec. XIA, XIB, or XIC depending on whether method A, B, or C discussed above was used. The corresponding values of λ_+ are listed in subsection L+M.

Because current experiments tend to use the (λ_+, λ_0) parametrization, we have added a subsection L0 for λ_0 results. Wherever possible we have converted $\xi(0)$ results into λ_0 results and vice versa.

(b) K_{e3} experiments.

Analysis of K_{e3} data is simpler than that of $K_{\mu 3}$ because the second term of the matrix element assuming a pure vector current [Eq. (2) above] can be neglected. Here f_+ is usually assumed to be linear in t, and the linear coefficient λ_+ of Eq. (3) is determined.

If we remove the assumption of a pure vector current, then the matrix element for the decay, in addition to the terms in Eq. (2), would contain

$$+2m_K(f_S\bar{u}_l(1+\gamma_5)u_\nu + (2f_T/m_K)(P_K)_\lambda(P_\pi)_\mu\bar{u}_l\sigma_{\lambda\mu}(1+\gamma_5)u_\nu ,$$

where f_S is the scalar form factor, and f_T is the tensor form factor. In the case of the K_{e3} decays where the f_- term can be neglected, experiments have yielded limits on $|f_S/f_+|$ and $|f_T/f_+|$.

The K_{e3} results for λ_+, $|f_S/f_+|$, and $|f_T/f_+|$ are listed in the subsections L+M, FS, and FT, respectively of the $K^\pm$ and K_L^0 sections of the Stable Particle Data Card Listings.

See also the Note on $K_{l3}^\pm$ and K_{l3}^0 Form Factors in the $K^\pm$ section of the Stable Particle Data Card Listings for additional discussion of the $K_{\mu 3}^0$ parameters, correlations, and conversion between parametrization and also for a comparison of the experimental results.

3. CP violation in K^0 decays

We list parameters for four different reactions in which CP can be tested [for details, see Okun and Rubbia (1967), Steinberger (1969), and Wolfenstein (1969)].

(a) $K_S \to \pi^+\pi^-\pi^0$.

The quantity measured here is the ratio of amplitudes

$$A_S(K_S \to \pi^+\pi^-\pi^0)/A_L(K_L \to \pi^+\pi^-\pi^0) \equiv x + iy . \qquad (4)$$

If CPT invariance holds and there is no $I=3$ state present, then x can be neglected and CP violation would be observed as a nonzero y. We give the result for Eq. (4) in the K_L^0 section of the Stable Particle Table and under Branching Ratio $R4$ in the K_S^0 section of the Stable Particle Data Card Listings. Our procedure is to assume that $x=0$, and to list $(A_S/A_L)^2$ in the form of a branching ratio.

(b) Charge asymmetry in $K_L \to 3\pi$ decays.

As mentioned above, the presence of a term in $(s_2 - s_1)$ in expression (1) describing the Dalitz plot distribution for $\tau^\pm, \tau^0$ decays of K mesons would be an indication of CP violation. Experimenters have used several forms for this CP-violation term. As described in the mini-review in the $K^\pm$ section of the Stable Particle Data Card Listings, we have converted all results to coefficient j in Eq. (1) above. The latter is listed among the CP-violating parameters at the back of the K_L^0 section of the Stable Particle Data Card Listings. Note that only upper limits have been reported for this quantity.

(c) Asymmetry in the $K_L \to \pi^\mp l^\pm \nu$ decays.

The quantity measured and compiled here is

$$\delta = \frac{\Gamma(K_L \to \pi^- l^+ \nu) - \Gamma(K_L \to \pi^+ l^- \nu)}{\Gamma(K_L \to \pi^- l^+ \nu) + \Gamma(K_L \to \pi^+ l^- \nu)} .$$

This asymmetry violates CP invariance. If CPT is good, for a pure K_L^0 beam, δ can be written as

$$\delta = 2[(1 - |x|^2)/(|1-x|^2)]\,\mathrm{Re}\epsilon ,$$

where x is the $\Delta S = \Delta Q$-violating parameter defined in section B.4, and ϵ is the parameter of the expansion

$$|K_L\rangle = [(1+\epsilon)|K\rangle - (1-\epsilon)|\bar{K}\rangle]/[2(1+|\epsilon|^2)]^{1/2}, \qquad (5a)$$

$$|K_S\rangle = [(1+\epsilon)|K\rangle + (1-\epsilon)|\bar{K}\rangle]/[2(1+|\epsilon|^2)]^{1/2}. \qquad (5b)$$

We give δ in the Addendum to the Stable Particle Table. In addition, in the K_L^0 CP-violation section of the Stable Particle Data Card Listings, we list δ separately for $K_L^0 \to \pi\mu\nu$ and $K_L^0 \to \pi e \nu$.

(d) $K_L \to 2\pi$ decay.

The relevant parameters are

$$\eta_{+-} = A(K_L \to \pi^+\pi^-)/A(K_S \to \pi^+\pi^-) = |\eta_{+-}|\exp(i\phi_{+-}) ,$$

$$\eta_{00} = A(K_L \to \pi^0\pi^0)/A(K_S \to \pi^0\pi^0) = |\eta_{00}|\exp(i\phi_{00}) ,$$

ϵ, defined in Eqs. (5) above, and

$$\epsilon' = \tfrac{1}{2} i\sqrt{2}\, \exp[i(\delta_2 - \delta_0)]\,\mathrm{Im}(A_2/A_0) .$$

Here, A_i and δ_i are the amplitude and phase of $\pi\pi$ scattering at the K mass, defined by

$$\langle I=0|T|K\rangle = \exp(i\delta_0)A_0 ,$$

$$\langle I=2|T|K\rangle = \exp(i\delta_2)A_2 .$$

Wu and Yang (1964) have derived the relationships

$$\eta_{+-} = \epsilon + \epsilon', \quad \eta_{00} = \epsilon - 2\epsilon' .$$

We give η_{+-}, η_{00}, ϕ_{+-}, and ϕ_{00} in the Addendum to the Stable Particle Table. The phases are measured directly, whereas the magnitudes η_{+-} and η_{00} are derived parameters. We use, as far as we can, the directly measured quantities as input and calculate η_{+-} and η_{00} from the values given by our constrained fits. Therefore, if one looks at the Data Card Listings, most of the $|\eta|$ measurements appear in the form of branching ratios, with appropriate comments. We then give the values of η_{+-} and $|\eta_{00}|^2$ in a separate list at the end of the CP-violating parameters section of the K_L^0 section of the Stable Particle Data Card Listings.

4. $\Delta S = \Delta Q$ rule in K^0 decays

The relative amount of $\Delta S \neq \Delta Q$ component present is measured by the parameter x, defined as

$$x = A(\bar{K}^0 \to \pi^- l^+ \nu)/A(K^0 \to \pi^- l^+ \nu) .$$

We list Re$\{x\}$ and Im$\{x\}$ for both K_{e3} and $K_{\mu 3}$ at the end of the Stable Particle Data Card Listings and give values in the Addendum to the Stable Particle Table.

C. η-decay parameters

1. C-violation in η decays

As a test of possible C-violation in electromagnetic interactions, a number of experiments have looked for possible charge asymmetries in the decays $\eta \to \pi^+\pi^-\pi^0$ and $\eta \to \pi^+\pi^-\gamma$. We list the following parameters:

(a) The left-right asymmetry

$$A = (N^+ - N^-)/(N^+ + N^-) ,$$

where $N^{(\pm)}$ means the number of events with the $\pi^{(\pm)}$ energy greater than the $\pi^{(\mp)}$ energy in the η rest frame.

(b) The sextant asymmetry

$$A_s = \frac{N_1 + N_3 + N_5 - N_2 - N_4 - N_6}{N_1 + N_2 + N_3 + N_4 + N_5 + N_6}$$

for the decay $\eta \to \pi^+\pi^-\pi^0$. The numbers refer to the sextants of the Dalitz plot [see, for example, Layter (1972)]. A_s is sensitive to an $I = 0$ C-violating asymmetry.

(c) The quadrant asymmetry A_q, defined in a similar way as A_s, but with each sector of the Dalitz plot now containing $\pi/2$ rather than $\pi/3$ radians. A_q is sensitive to an $I = 2$ C-violating final state.

(d) The d-wave contribution to the C-violating amplitude in the decay $\eta \to \pi^+\pi^-\gamma$. The upper limit for this contribution is measured by the parameter β, defined by

$$dN/d\,|\cos\theta\,| \propto \sin^2\theta(1 + \beta\cos^2\theta) ,$$

where θ is the angle between the π^+ and the γ in the dipion center of mass. A term proportional to $\cos^2\theta$ could also be due to p- and f-wave interference.

We list A for the decay modes $\eta \to \pi^+\pi^-\pi^0$ and $\eta \to \pi^+\pi^-\gamma$, A_s and A_q for the decay $\eta \to \pi^+\pi^-\pi^0$, and β for the decay $\eta \to \pi^+\pi^-\gamma$ in the η section of the Stable Particle Data Card Listings.

2. Dalitz plot for $\eta \to \pi^+ \pi^- \pi^0$

The Dalitz plot for the decay $\eta \to \pi^+\pi^-\pi^0$ may be fit by the distribution

$$|M(x,y)|^2 \propto 1 + ay + by^2 + cx + dx^2 + exy .$$

Here,

$$x = \sqrt{3}\,(T_+ - T_-)/Q , \quad y = (3T_0/Q) - 1 ,$$

T_+, T_-, T_0 are the kinetic energies of the π^+, π^-, and π^0 in the η rest system, and $Q = m_\eta - m_{\pi^+} - m_{\pi^-} - m_{\pi^0}$. The coefficient of the term linear in x is sensitive to C-violation due to an $I = 0$ or $I = 2$ final state. We list papers presenting determinations of the parameters a, b, c, and d in the η section of the Stable Particle Data Card Listings. However, we do not tabulate values of these parameters because the assumptions made by different authors are not compatible and do not allow comparison of the numerical values.

3. Dalitz plot for $\eta \to \pi^+\pi^-\gamma$

The Dalitz plot for the decay $\eta \to \pi^+\pi^-\gamma$ may be fit to the expression

$$|M|^2 \propto 1 + 2\alpha z ,$$

where

$$z = \frac{2}{3}\sum_{i=1}^{3}\left[\frac{3}{m_\eta - 3m_\pi}(E_i - \tfrac{1}{3}m_\eta)\right]^2 = \frac{\rho^2}{\rho^2_{\max}} .$$

Here E_i is the energy of the ith pion in the η rest frame, and ρ is the distance to the center of the Dalitz plot. We list the parameter α in the η section of the Stable Particle Data Card Listings.

D. Baryon-decay parameters

1. A/V ratio for baryon leptonic decays

Consider the decay

$$B_i \to B_f + l + \nu .$$

Assuming V, A theory, neglecting "induced" scalar, "induced" pseudoscalar, and axial weak-magnetism terms, and neglecting the q^2 dependence of the form factors, the baryon part of the matrix element for these decays may be written [Goldberger and Treiman (1958)] as

$$\langle B_f\,|\gamma_\lambda(g_V - g_A\gamma_5) + (g_W/m_{B_i})\sigma^{\lambda\nu}q_\nu\,|B_i\rangle ,$$

where B_i and B_f represent initial and final baryons, g_A and g_V the axial and vector coupling constants, g_W the weak magnetism coupling constant, and q_ν the sum of the lepton momenta. Here the Pauli representation is used for the γ matrices. The ratio g_A/g_V may be written as

$$g_A/g_V = |g_A/g_V|\,\exp(i\phi) ,$$

where ϕ is $0 + n\pi$ if time reversal holds [see Jackson *et al.* (1957)].

Experiments on the leptonic decays of baryons other than the neutron have generally assumed ϕ to be either 0 or π, and have thus measured the magnitude and sign of g_A/g_V. In studying neutron beta decay, however, experiments have been sensitive enough to measure ϕ more precisely, and we include the phase angle in our Listings for this case. It is consistent with time-reversal invariance, and by using the above definition of the matrix element with the Pauli representations, the value of g_A/g_V in neutron beta decay is negative.

Due to statistical limitation the weak magnetism form factor g_W is usually assumed from CVC and SU(3), so only g_A and g_V are determined experimentally. This determination is accomplished in a variety of ways.

(a) The lepton-neutrino angular correlation provides a measure of the absolute value of g_A/g_V [for relevant formulas, see, e.g., Albright (1959)].

(b) The up-down asymmetry of the lepton from polarized baryon decays provides a measure of g_A/g_V with its sign [for relevant formulas, see, e.g., Albright

(1959)].

(c) The lepton spectrum, given enough statistics, provides a measure of g_A/g_V with its sign [for relevant formulas, see, e.g., Bender (1968)].

(d) The polarization of the decay baryon, from polarized or unpolarized initial baryon, also provides g_A/g_V with its sign [for formulas, see, e.g., Willis and Thompson (1968)].

(e) The presence of a term proportional to

$$\sigma_{B_i} \cdot (\mathbf{p}_e \times \mathbf{p}_\nu),$$

where the initial baryon is polarized or

$$\sigma_{B_f} \cdot (\mathbf{p}_e \times \mathbf{p}_\nu),$$

where the polarization of the decay baryon is observed provides a measure of the deviation of ϕ from 0 or π, and is thus a test of time-reversal invariance [see, e.g., Willis and Thompson (1968)].

We compile the ratio g_A/g_V with its sign, for those decays for which it has been measured.

All the coupling constants and decay rates for baryon leptonic decays are related by Cabibbo's theory [Cabibbo (1963)], extended to six quarks (and three mixing angles) by Kobayashi and Maskawa (1973). A recent fit to this theory has been done by Shrock and Wang (1978).

2. Asymmetry parameters in nonleptonic hyperon decays

The transition matrix for the hyperon decay may be written as

$$M = s + p(\sigma \cdot \mathbf{q}), \tag{6}$$

where s and p are the parity-changing and the parity-conserving amplitudes, respectively; σ is the Pauli spin operator, and $\mathbf{q}$ is a unit vector along the direction of the decay baryon in the hyperon rest frame.

The asymmetry parameters are defined by the relations

$$\alpha = 2\,\mathrm{Re}(s^*p)/(|s|^2 + |p|^2),$$

$$\beta = 2\,\mathrm{Im}(s^*p)/(|s|^2 + |p|^2),$$

$$\gamma = (|s|^2 - |p|^2)/(|s|^2 + |p|^2).$$

With the transition matrix (6), the angular distribution of the decay baryon, in the hyperon rest system, is of the form

$$I = 1 + \alpha \mathbf{P}_Y \cdot \mathbf{q},$$

where $\mathbf{P}_Y = \langle Y|\sigma|Y\rangle$ is the hyperon polarization.

In the notation of Lee and Yang (1957) the polarization $\mathbf{P}_B$ of the decay baryon is[2]

$$\mathbf{P}_B = \frac{(\alpha + \mathbf{P}_Y \cdot \mathbf{q})\mathbf{q} + \beta(\mathbf{P}_Y \times \mathbf{q}) + \gamma\mathbf{q} \times (\mathbf{P}_Y \times \mathbf{q})}{1 + \alpha \mathbf{P}_Y \cdot \mathbf{q}},$$

where $\mathbf{P}_B$ is defined in that rest system of the baryon obtained by a Lorentz transformation along $\mathbf{q}$ from the hyperon rest system in which $\mathbf{q}$ and $\mathbf{P}_Y$ are defined.

[2]Note that Lee and Yang (1957) contains a misprint. The minus sign in the definition of β should be replaced by a 2. In addition, our unit vector $\mathbf{q}$ is the direction of the baryon, whereas their unit vector $\mathbf{p}$ is the direction of the pion.

Note that α is the helicity of the decay baryon for unpolarized hyperons.

The three parameters α, β, and γ satisfy the relation

$$\alpha^2 + \beta^2 + \gamma^2 = 1.$$

It is then convenient to describe hyperon nonleptonic decays in terms of the two independent parameters α and the angle ϕ defined by

$$\beta = (1 - \alpha^2)^{1/2} \sin\phi,$$

$$\gamma = (1 - \alpha^2)^{1/2} \cos\phi,$$

which has a more nearly gaussian distribution than β or γ. Evidently

$$-\tfrac{1}{2}\pi \le \phi \le \tfrac{1}{2}\pi \text{ for } \gamma > 0,$$

$$+\tfrac{1}{2}\pi \le \phi \le \tfrac{3}{2}\pi \text{ for } \gamma < 0.$$

In discussing time-reversal invariance, the quantity of interest is Δ, defined by

$$\alpha = 2|s||p|\cos\Delta/(|s|^2 + |p|^2),$$

$$\beta = -2|s||p|\sin\Delta/(|s|^2 + |p|^2);$$

that is, Δ is the phase angle of s relative to p. Evidently

$$-\tfrac{1}{2}\pi \le \Delta \le \tfrac{1}{2}\pi \text{ for } \alpha > 0,$$

$$+\tfrac{1}{2}\pi \le \Delta \le \tfrac{3}{2}\pi \text{ for } \alpha < 0.$$

Under the assumption of time-reversal invariance, the angle Δ must satisfy the relation

$$\Delta = \delta_s - \delta_p,$$

modulo π, where δ_s and δ_p are the pion–baryon scattering phase shifts at the appropriate energy and for the appropriate isospin state. For Λ decay, assuming the validity of the $|\Delta I| = \frac{1}{2}$ rule,

$$\Delta = \delta_s - \delta_p = (7.0 \pm 1.0) \text{ deg.}^3$$

In the Stable Particle Data Card Listings we give α and ϕ for each decay since they are the most closely related to the experiments and are essentially uncorrelated. Whenever necessary we have changed the signs of the reported values, so as to agree with our conventions. In the Stable Particle Table we give α, ϕ, and Δ with errors; and for convenience we also give the central value of γ, without an error.

VII. STATISTICAL PROCEDURES

We divide this discussion on obtaining averages and errors into two sections:

A. the unconstrained case, or "simple averaging", and

B. the constrained case.

In what follows, the term "error" means one standard deviation (1σ); that is, for central value $\bar{x}$ and error $\delta\bar{x}$, the range $\bar{x} \pm \delta\bar{x}$ constitutes a 68.3% confidence interval.

[3]This value for $\delta_s - \delta_p$ is derived from the phase-shift analyses by Ayed (1976). The error is our estimation of the uncertainty allowing for possible correlations.

A. Unconstrained averaging

We first describe the standard procedure we have used for several years to determine averages and errors. We then discuss a second method, which we feel offers a less conservative, but possibly more accurate, estimate of errors.

1. Standard procedure—Gaussian distribution with scale factor

We begin by assuming that measurements of a given quantity obey a gaussian distribution, and thus we calculate a weighted average and error

$$\bar{x} \pm \delta\bar{x} = \left(\sum_i w_i x_i \Big/ \sum_i w_i\right) \pm \left(\sum_i w_i\right)^{-1/2}, \quad w_i = [1/(\delta x_i)^2], \tag{1}$$

where x_i and δx_i are the value and error, respectively, reported by the ith experiment, and the sums run over N experiments. We also calculate χ^2 and compare it with its expectation value of $N-1$.

If $\chi^2/(N-1)$ is less than or equal to 1, and there are no known problems with the data, we accept the above results.

If $\chi^2/(N-1)$ is very large, or if there is prior knowledge of extremely large inconsistencies between experiments, we may choose not to average the data at all. Alternatively, we may quote the calculated average, but then give an educated guess as to the error; such a guess is generally a quite conservative estimate designed to take into account known problems with the data.

Finally, if $\chi^2/(N-1)$ is greater than 1, but not to such a large extent, we still average the data, but then try to make up for this fact in two ways:

(i) We plot an ideogram to guide the reader in deciding which data might be rejected before selected averages are made. An example of such an ideogram is given in Fig. 3 below. Each experiment appearing in the plot is represented by a gaussian with central value x_i, error δx_i, and area proportional to $1/\delta x_i$. The choice of area is a somewhat arbitrary one; it is based on the assumption that an experimenter will work to reduce his (or her) systematic errors until they are slightly smaller (but seldom much smaller) than the statistical errors. Thus, as a bubble chamber physicist gets more events, he (or she) will use them both to reduce the statistical errors and to study the biases. Our confidence that a significant systematic error has not been made in a given experiment, as compared with other contradictory experiments, then tends to go up as $1/\delta x_i$.

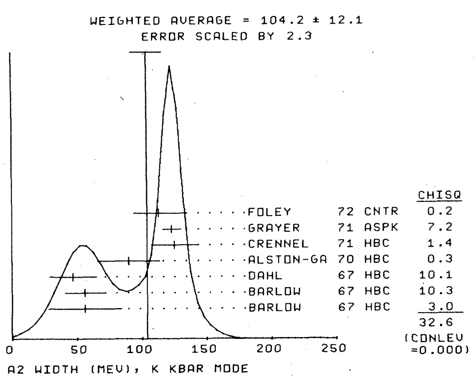

FIG. 3. Ideogram of early measurements of the A_2 width, as determined from the $K\bar{K}$ mode. The vertical line indicates the position of the weighted average, while the horizontal bar atop the line gives the error in the average after scaling by the SCALE factor. Only those experiments indicated by + error flags were precise enough to be accepted in the calculation of the SCALE factor; the column on the far right gives the x^2 contribution of each of these experiments. Occasionally, less precise experiments are included in the calculation of the weighted average, but not SCALE; they have ⊥ error flags.

But why not assign a weight $1/\delta x_i^2$, as is done when computing a weighted average? We feel that this is equivalent to assuming that large systematic errors are as infrequent as large statistical fluctuations, and that this is unrealistic.

We emphasize the difference between least-squares averaging (where the weighting factor is the inverse square of the error) and the ideograms prepared for visual display. The former arithmetic is of course best if one has statistically distributed input, and yields a narrow gaussian distribution centered at the weighted mean. The ideogram (often multipeaked and certainly not gaussian) is based on the opposite hypothesis that some of the input is systematically in error. The idea behind least-squares averaging is that experiments 1, 2, 3, etc., are *all* valid (so we should multiply their probabilities). Our *ideograms* are based on the assumption that 1 *or* 2 *or* 3, etc., is valid, "hedged" with $1/\delta x_i$ betting odds; we then add their probabilities. Both approaches cannot simultaneously be right; we leave it to the reader to choose. A glance at the ideogram will show, however, that the discrepancy is often not severe for reasonably distributed input.

(ii) The second way in which we try to take account of $\chi^2/(N-1)$ being greater than 1 is to scale up our quoted error $\delta\bar{x}$ in Eq. (1) by a factor

$$\text{SCALE} = [\chi^2/(N-1)]^{1/2}. \tag{2}$$

Our reasoning is as follows. Since we do not know which one or more of the experiments are wrong, we assume that all experimentalists underestimated their errors by the same scale factor (2). If we scale up all input errors by this factor, χ^2 returns to $N-1$, and of course the output error scales up by the same factor.

If all the experiments have errors of about the same size, the above (straightforward) procedure for calculating SCALE is carried out. If, however, we are to combine experiments with widely varying errors, we must modify the procedure slightly. This is because it is the more precise experiments that most influence not only the average value $\bar{x}$, but also the error $\delta\bar{x}$. Now, on the average, the low-precision experiments each contribute about unity to *both* the numerator and the denominator of SCALE, hence the χ^2 contribution of the sensitive experiments is diluted, i.e., reduced. Therefore, we evaluate SCALE by using *only* experiments for which the errors are not much greater than those of the more precise experiments. Explicitly, to calculate SCALE we use only the most sensitive experiments, i.e., those with errors less than δ_0, where the ceiling δ_0 is (arbitrarily) chosen to be

$$\delta_0 = 3N^{1/2}\delta\bar{x} .$$

Here $\delta\bar{x}$ is the unscaled error of the mean of all the experiments. Note that if each experiment had the same error δx_i, then $\delta\bar{x}$ would be $\delta x_i/N^{1/2}$, so each individual experiment would be well under the ceiling on SCALE.

This scaling approach has the property that if there are two values with comparable errors separated by much more than their stated errors (with or without a number of other experiments of lower accuracy), the error on the mean value $\delta\bar{x}$ is increased so that it is approximately half the interval between the two discrepant values.

We wish to emphasize the fact that our scaling procedures for *errors* in no way affect central values. In addition, if one wishes to recover the unscaled error $\delta\bar{x}$, one need only divide the given error by the SCALE factor for that error.

2. A second procedure—Student's distribution

The second method of averaging data, described in detail in Roos *et al.* (1975), relies upon an empirical determination of the distribution of the residuals for the ensemble of data appearing in the Review. The residual for the ith measurement of a quantity with average value $\bar{x}$ is defined as

$$h_i = (x_i - \bar{x})/\delta x_i .$$

Roos *et al.* select several different subsamples of the data, and show that the residuals for *each* subsample have approximately the same properties; in particular, their first few even moments are similar. Since the distributions have longer tails than a gaussian, the authors choose to represent them by a distribution function having such a property, namely the Student distribution

$$S_n(h/c) = K\left[1 + \frac{(h/c)^2}{n}\right]^{-(n+1)/2} . \quad (3)$$

Here K is a normalization constant, and n and c are parameters which the authors then fit to the combined sample of data. The resulting empirical distribution is

$$S_{10}(h/1.11) = 0.351\left[1 + \frac{(h/1.11)^2}{10}\right]^{-11/2} . \quad (4)$$

Note that the shape of S_{10} is somewhere between that of a gaussian ($=S_\infty$) and that of a Breit–Wigner ($=S_1$).

The proposed method of averaging the data for a given quantity then consists of finding the value of $\bar{x}$ which maximizes the log-likelihood function

$$\log \mathcal{L}(\{x_i\}\,|\,\bar{x}) = \sum_i \log\left[S_{10}\left(\frac{x_i - \bar{x}}{1.11\delta x_i}\right)\right]; \quad (5)$$

the sum here is again taken over all N measurements of x. The error $\delta\bar{x}$ is determined by finding the variation in $\bar{x}$ needed to decrease the log-likelihood by 1/2:

$$\log \mathcal{L}(\{x_i\}\,|\,\bar{x}) - \log \mathcal{L}(\{x_i\}\,|\,\bar{x} \pm \delta\bar{x}) = \tfrac{1}{2} . \quad (6)$$

3. Comparison of procedures

Both of the procedures described above adopt a partially empirical approach to the problem that measured values for the quantities tabulated in this Review do not exhibit the gaussian behavior naively expected. (This problem, it should be noted, persists even when careful attempts are made to resolve difficulties and inconsistencies in the data prior to averaging.)

The first approach operates on a quantity-by-quantity basis and adjusts the error in each case so that no scaled $\chi^2/(N-1)$ is greater than 1. This is obviously rather conservative, since even if the data obeyed a gaussian distribution, about half of the quantities would be expected to have $\chi^2/(N-1) > 1$.

The second approach, on the other hand, assumes that (provided we first eliminate quantities with obvious, known problems) all quantities have the same theoretical distribution function, namely the fairly long-tailed $S_{10}(h/1.11)$. With this supposition, if a *particular* quantity has a large χ^2, it is assumed to be just a happenstance, occasioned by a random fluctuation into the long tails, and no special scaling for this quantity is done. This procedure thus results in generally smaller, or less conservative, error estimates for quantities having $\chi^2/(N-1) > 1$. (However, it should be noted that, because of the overall scale of 1.11 appearing in the empirical Student's distribution, the errors for quantities with $\chi^2/(N-1) \leq 1$ are actually increased by about 10%.) Table 3 shows some comparisons of sample results from the two procedures, using data from the 1978 edition of the Review. Shifts in both $\bar{x}$ and $\delta\bar{x}$ can be observed, especially where SCALE > 1.

Since the second procedure is a significant departure from the traditional method, we have repeated the previously adopted approach: in the Data Card Listings we give the average-and-error for each quantity cal-

TABLE III. Comparison of procedures (data from 1978 edition).

Particle property	Pure gaussian $\bar{x} \pm \delta\bar{x}$	Standard method: gaussian + scale factor $\bar{x} \pm \delta\bar{x}$	Scale	Proposed method: Student's distribution $\bar{x} \pm \delta\bar{x}$
ρ^0 mass (MeV)	770.23 ± 0.65	770.23 ± 0.88	1.3	770.25 ± 0.82
η' mass (MeV)	957.57 ± 0.25	957.57 ± 0.25	1.0	957.57 ± 0.28
ϕ mass (MeV)	1019.62 ± 0.16	1019.62 ± 0.24	1.5	1019.68 ± 0.21
K_L^0 mean life(10^{-8}s)	5.158 ± 0.042	5.158 ± 0.042	1.0	5.158 ± 0.046
ν^+ mean life(10^{-10}s)	0.8015 ± 0.0053	0.8015 ± 0.0053	1.0	0.8015 ± 0.0058
χ^- mean life (10^{-10}s)	1.483 ± 0.011	1.483 ± 0.015	1.4	1.481 ± 0.012
$K^\pm \to \pi^\pm\pi^+\pi^-$ (%)	5.521 ± 0.075	5.521 ± 0.098	1.3	5.533 ± 0.089
$\Lambda \to p\pi^-$(%)	63.99 ± 0.49	63.99 ± 0.49	1.0	63.98 ± 0.55

culated both ways; the standard way is labelled at the left with the code "AVG", while the second way is labelled "STUDENT". In the Tables of Particle Properties, we continue to use the standard procedure—gaussian with SCALE factor. As in the past, a SCALE factor greater than 1 is indicated by the appearance of "$S = \ldots$" next to the value and error.

B. Constrained fits

Except for trivial cases, all branching ratios and rate measurements are analyzed by the computer program AHR. This program makes a simultaneous least-squares fit to all the data, and outputs the partial-decay fractions $\overline{P}_i$, width Γ, partial widths Γ_i, and their error matrix.

The original version of AHR was written by J. Peter Berge. It is documented separately, and we wish here only to give the simplest nontrivial example that permits us to comment on the error matrix and the scale factor.

Assume that a state has only three partial-decay fractions, P_1, P_2, and P_3 ($\Sigma P_i = 1$), which have been measured in four different ratios, $R_1, \ldots, R_4$, where, e.g., $R_1 = P_1/P_2$, $R_2 = P_1/P_3$, etc.[4] Further assume that *each* ratio has been measured by N experiments (we designate each experiment with a subscript x, e.g., R_{1x}). Then AHR finds the best values of P_1, P_2, and P_3 by minimizing χ^2, namely

$$\chi^2 = \sum_{r=1}^{4} \left[\sum_{x=1}^{N} \left(\frac{R_{rx} - R_r(P_1, P_2, P_3)}{\delta R_{rx}} \right)^2 \right]. \quad (7)$$

In addition to the fitted values $\overline{P}_i$, the program calculates an error matrix $\langle \delta\overline{P}_i \delta\overline{P}_j \rangle$. We tabulate the diagonal elements $\delta\overline{P}_i = \langle \delta\overline{P}_i \delta\overline{P}_i \rangle^{1/2}$ (except that some errors are scaled according to Eq. (2) as discussed below). In the listings we give the complete error matrix; we also calculate the fitted value of each ratio, for comparison with the input data, and list it below the relevant input, along with a simple unconstrained average of the same input.

Two further comments on the example above.

(1) There was no connection between measurements of the width and the branching ratios. But often we also have information on partial widths Γ_i as well as total width Γ. In this case AHR must introduce Γ as a parameter into the fit, along with the relations $\Gamma_i = \Gamma P_i$, $\Sigma\Gamma_i = \Gamma$. When appropriate, we tabulate the Γ_i along with the P_i, and give error matrices in the listings.

(2) Note that we do *not* allow for correlations between input data. We *do* try to pick those ratios and widths which are as independent and as close to the original data as possible.

In *asymmetric* errors, we use a continuous function of $\delta(P)^+$ and $\delta(P)^-$ in the fitting. When no errors are reported, we merely list the data for inspection.

Hyperon-decay parameters. The program AHR handles any type of input, α, ϕ, Δ, β, or γ, according to the definitions of Sec. VI. If for a particular hyperon decay there are data for more than two of the decay parameters, they are analyzed by using the constraint

$$\alpha^2 + \beta^2 + \gamma^2 = 1 .$$

Inconsistent constrained data. According to our simple example, which led to Eq. (7), the double sum for χ^2 is summed over experiments $x = 1$ to N, leaving a single sum over ratios

$$\chi^2 = \sum_r \chi_r^2 .$$

Even before fitting, some of the χ_r^2 may be too large. But if we scaled them before fitting, then the scaling would move the central value, contrary to our policy. So we do not scale until after the first fit; then, knowing the fitted χ_r^2 and its expectation value $\langle \chi_r^2 \rangle$ we form SCALE factors (just as before), i.e.,

$$(\mathrm{SCALE})_r^2 = \chi_r^2 / \langle \chi_r^2 \rangle ,$$

and if any $(\mathrm{SCALE})_r$ is greater than 1, all N of the measurements of that particular ratio are equally penalized by having their errors increased by $(\mathrm{SCALE})_r$. Program AHR then recycles on all the data, those with errors unchanged as well as those with errors increased. We then get new values, $\delta\overline{P}_i'$ for the errors in the partial decay modes.

Because of the constraint ($\Sigma P_i = 1$) some SCALE factors may still be greater than 1 even after this second pass. If this is so, the whole procedure (i.e., increasing errors by the new SCALE factors and recycling through AHR) is repeated.

At the end of AHR's final pass we have two measures of the errors for the $\overline{P}_i$. One is, of course, the $\delta\overline{P}_i'$, i.e., the errors in the final fitted values $\overline{P}_i'$ which include the effects of scaling the input errors. The other measure of the errors is $(\overline{P}_i - \overline{P}_i')$, i.e., the *shift* in the central values of the ith mode between the first (unscaled) fit and the final (scaled) fit. In practice we find that on the average these two measures of the uncertainty are about equal. Rather than selecting just one or the other, our tabulated errors are given by the combination

$$(\delta\overline{P}_i)_{tab} = [\delta\overline{P}_i'^2 + (\overline{P}_i - \overline{P}_i')^2]^{1/2} ,$$

where $\overline{P}_i$ is the fitted value of the ith partial-decay mode before scaling, $\overline{P}_i'$ is its value after scaling, and $\delta\overline{P}_i'$ is the error in $\overline{P}_i'$. The SCALE factors we finally list in such cases are defined by

$$(\mathrm{SCALE})_i = (\delta\overline{P}_i)_{tab} / \delta\overline{P}_i .$$

However, in line with our policy of not letting SCALE affect the central values, we give the values of $\overline{P}_i$ obtained from the original (unscaled) fits. (The differences between the $\overline{P}_i$ calculated with either the scaled or the unscaled errors are, of course, always within the tabulated errors, $(\delta\overline{P}_i)_{tab}$.)

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We thank all those who have assisted in the many

[4]We can handle any R of the form $R = \Sigma\alpha_i P_i / \Sigma\beta_i P_i'$, where α_i and β_i are constants, usually 1 or 0.

phases of preparing this Review. In particular, we acknowledge the usefulness of feedback from the physics community, especially those who have made suggestions or pointed out errors. The comments and suggestions of Dr. Goldschmidt-Clermont were particularly helpful. The European members of the Particle Data Group wish to acknowledge the generous support of CERN, in particular Division EP and Dr. A. Günther and his services.

REFERENCES

Albright, C. H., 1959, Phys. Rev. **115**, 750.

Ayed, R., 1976, CEA-N-192, Saclay thesis.

Barbaro-Galtieri, A., 1968, "Baryon resonances," in: *Advances in Particle Physics*, eds. R. L. Cool and R. E. Marshak (Wiley, New York), Vol. 2. See specifically, Table IV and Figs. 10 and 12.

Barrelet, E., 1972, Nuovo Cim. **8A**, 331.

Bender, I., V. Linke and H. J. Rothe, 1968, Z. Physik **212**, 190.

Cabibbo, N., 1963, Phys. Rev. Lett. **10**, 531.

Cabibbo, N., and A. Maksymowicz, 1964, Phys. Lett. **9**, 352.

Chounet, L. M., J. M. Gaillard and M. K. Gaillard, 1972, Phys. Rep. **4C**, 199.

Fearing, H. W., E. Fischbach and J. Smith, 1970, Phys. Rev. D **2**, 542.

Gasiorowicz, S., 1966, *Elementary Particle Physics* (Wiley, New York).

Giacomelli, G., *et al*., 1974, Nucl. Phys. **B71**, 138.

Goldberger, M. L., and S. B. Treiman, 1958, Phys. Rev. **11**, 354.

Jackson, J. D., S. D. Treiman and H. W. Wyld Jr., 1957, Phys. Rev. **106**, 517.

Jackson, J. D., 1964, Nuovo Cim. **34**, 1644.

Källén, G., 1964, *Elementary Particle Physics* (Addison-Wesley, Reading, MA).

Kinoshita, T., and A. Sirlin, 1957, Phys. Rev. **108**, 844.

Kobayashi, M., and T. Maskawa, 1973, Progr. Theor. Phys. **49**, 652.

Layter, J. G., J. A. Appel, A. Kotlewski, W. Lee, S. Stein and J. J. Thaler, 1972, Phys. Rev. Lett. **29**, 316.

Lee, T. D., and C. N. Yang, 1957, Phys. Rev. **108**, 1615.

Levi-Setti, R., June 1969, Rapporteur talk at the Lund Intern. Conf. on Particle Physics (Lund).

Martin, B. R., 1975, Nucl. Phys. **B94**, 413.

Okun, L. B., and C. Rubbia, 1967, Proc. Heidelberg Conf. on Elementary Particles, p. 301.

Particle Data Group: N. Barash-Schmidt, A. Barbaro-Galtieri, L. R. Price, A. H. Rosenfeld, P. Söding, C. G. Wohl, M. Roos and G. Conforto, 1969, Rev. Mod. Phys. **41**, 109.

Particle Data Group: C. Bricman, C. Dionisi, R. J. Hemingway, M. Mazzucato, L. Montanet, N. Barash-Schmidt, R. L. Crawford, M. Roos, A. Barbaro-Galtieri, C. P. Horne, R. L. Kelly, M. J. Losty, A. Rittenberg, T. G. Trippe, G. P. Yost, B. Armstrong, 1978, Phys. Letts. **75B**.

Pišút, J., and M. Roos, 1968, Nucl. Phys. **B6**, 325.

Roos, M., M. Hietanen and J. Luoma, 1975, Physica Fennica **10**, 21.

Roper, L. D., R. M. Wright and B. T. Feld, 1965, Phys. Rev. **138**, B190.

Rosenfeld, A. H., 1975, Ann. Rev. Nucl. Sci. **25**, 555.

Shrock, R. E., and Ling-Lie Wang, 1978, Phys. Rev. Lett. **41**, 692.

Steinberger, J., 1969, CERN Topical Conf. on Weak Interactions, CERN 69-7, p. 291.

Weinberg, S., 1960, Phys. Rev. Lett. **4**, 87.

Willis, W., and J. Thompson, 1968, "Leptonic Decays of Elementary Particles," in: *Advances in Particle Physics*, eds. R. L. Cool and R. E. Marshak (Wiley, New York), Vol. 1, p. 295.

Wolfenstein, L., 1969, in: *Theory and Phenomenology in Particle Physics*, ed. A. Zichichi (Academic, New York), p. 218.

Wu, T. T., and C. N. Yang, 1964, Phys. Rev. Lett. **12**, 380.

TABLES OF PARTICLE PROPERTIES

April 1980

N. Barash-Schmidt, C. Bricman, R. L. Crawford, C. Dionisi, C. P. Horne, R. L. Kelly, M. J. Losty, M. Mazzucato, L. Montanet, A. Rittenberg, M. Roos, T. Shimada, T. G. Trippe, C. G. Wohl, G. P. Yost

(Closing date for data: Jan. 1, 1980)

Stable Particle Table

For additional parameters, see Addendum to this table.

Quantities in italics have changed by more than one (old) standard deviation since April 1978.

Particle	$I^G(J^P)C_n$ [a]	Mass (MeV) Mass^2 (GeV)^2	Mean life (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
			PHOTON			
γ	$0,1(1^-)-$	$0(<6\times10^{-22})$	——	stable		
			LEPTONS			
ν_e	$J=\frac{1}{2}$	$0(<0.00006)$	stable	stable		
			$(>3\times10^8 m_{\nu_e}(\text{MeV}))$			
e	$J=\frac{1}{2}$	0.5110034	stable	stable		
		±.0000014	$(>5\times10^{21}$y)			
ν_μ	$J=\frac{1}{2}$	$0(<0.57)$	stable	stable		
			$(>2.6\times10^4 m_{\nu_\mu}(\text{MeV}))$			
				$\mu^- \xrightarrow{d}$		
μ	$J=\frac{1}{2}$	105.65946	2.197120×10^{-6}	$e^-\bar{\nu}\nu$	(98.6 ±0.4)%	53
		±.00024	±.000077	$e^-\bar{\nu}\nu\gamma$	[e](1.4)%	53
		m^2= 0.01116392	$c\tau=6.5868\times10^4$	$e^-\gamma\gamma$	(<4)$\times10^{-6}$	53
		$m_\mu-m_{\pi^\pm}$= −33.9074		$e^-e^+e^-$	(<1.9)$\times10^{-9}$	53
		±.0012		$e^-\gamma$	(<1.9)$\times10^{-10}$	53
				$e^-\nu_e\bar{\nu}_\mu$	(<25)%	53
→				$\tau^- \xrightarrow{d}$		
τ	$J=\frac{1}{2}$ [f]	*1784*	$<2.3\times10^{-12}$	$\mu^-\bar{\nu}\nu$	(17.9 ±1.5)%	889
		±*4*		$e^-\bar{\nu}\nu$	(17.0 ±1.1)%	892
		m^2= *3.18*	$c\tau<0.07$	hadron$^-$ neutrals	(33 ±10)%	
				†[$\pi^-\nu$	(8.2 ±2.6)%]	887
				†[$\rho^-\nu$	(22 ±4)%]	723
				†[K^- neutrals	(small)]	
				$e^-\gamma+\mu^-\gamma$	(<12)%	892
				3(hadron$^\pm$) neutrals	(35 ±11)%	
				†[$\pi^-\rho^0\nu$	(4.2 ±1.3)%]	715
				†[$\pi^-\pi^-\pi^+\nu$ (incl. $\pi\rho\nu$)	(7 ±5)%]	864
				†[$\pi^-\pi^-\pi^+(\geq0\pi^0)\nu$	(18 ±7)%]	864
				(≥3chgd.) neutrals	(32 ±5)%	
				†[e^- chgd.parts.		
				$+\mu^-$ chgd.parts.	(<4)%]	
			NONSTRANGE MESONS [a]			
				$\pi^+ \xrightarrow{d}$		
$\pi^\pm$	$1^-(0^-)$	139.5669	2.6030×10^{-8}	$\mu^+\nu$	100 %	30
		±.0012	±.0023	$e^+\nu$	(1.267±0.023)$\times10^{-4}$	70
		m^2= 0.0194789	$c\tau$=780.4	$\mu^+\nu\gamma$	[e](1.24±0.25)$\times10^{-4}$	30
			$(\tau^+-\tau^-)/\bar{\tau}$=	$e^+\nu\pi^0$	(1.02±0.07)$\times10^{-8}$	5
			(0.05±0.07)%	$e^+\nu\gamma$	[e](*5.6 ±0.7*)$\times10^{-8}$	70
			(test of CPT)	$e^+\nu e^+e^-$	(< 5)$\times10^{-9}$	70
π^0	$1^-(0^-)+$	134.9626	0.828×10^{-16}	$\gamma\gamma$	(98.85±0.05)%	67
		±.0039	±.057 S=1.8*	γe^+e^-	(1.15±0.05)%	67
		m^2= 0.0182149	$c\tau=2.5\times10^{-6}$	$\gamma\gamma\gamma$	(<1.5)$\times10^{-6}$	67
		$m_{\pi^\pm}-m_{\pi^0}$= 4.6043		$e^+e^-e^+e^-$	[g](3.32)$\times10^{-5}$	67
		±.0037		$\gamma\gamma\gamma\gamma$	(<4)$\times10^{-5}$	67
				e^+e^-	(2.2 $^{+2.4}_{-1.1}$)$\times10^{-7}$	67
η	$0^+(0^-)+$	548.8	Γ=(0.85±0.12)keV	$\gamma\gamma$	[h](38.0 ±1.0)% S=1.2*	274
		±0.6	Neutral decays	$\pi^0\gamma\gamma$	[h](3.1 ±1.1)% S=1.2*	258
		S=1.4*	(71.0±0.7)%	$3\pi^0$	(29.9 ±1.1)% S=1.1*	180
		m^2= 0.3012	S=1.1*	$\pi^+\pi^-\pi^0$	(23.6 ±0.6)% S=1.1*	175
				$\pi^+\pi^-\gamma$	(4.89±0.13)% S=1.1*	236
				$e^+e^-\gamma$	(0.50±0.12)%	274
				$e^+e^-\pi^0$	(<4)$\times10^{-5}$	258
				$\pi^+\pi^-$	(<0.15)%	236
			Charged decays	$e^+e^-\pi^+\pi^-$	(0.1 ±0.1)%	236
			(29.0±0.7)%	$\pi^+\pi^-\pi^0\gamma$	(<6)$\times10^{-4}$	175
			S=1.1*	$\pi^+\pi^-\gamma\gamma$	(<0.2)%	236
				$\mu^+\mu^-$	(2.2 ±0.8)$\times10^{-5}$	253
				$\mu^+\mu^-\gamma$	(1.5 ±0.8)$\times10^{-4}$	253
				$\mu^+\mu^-\pi^0$	(<5)$\times10^{-4}$	211
				e^+e^-	(<3)$\times10^{-4}$	274

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)C_n$ [a]	Mass (MeV) Mass^2 (GeV)^2	Mean life (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
			STRANGE MESONS[a]			
				$K^+ \xrightarrow{d}$		
$K^\pm$	$\frac{1}{2}(0^-)$	493.669	1.2371×10^{-8}	$\mu^+\nu$	(63.50±0.16)%	236
		±0.015	±.0026 S=1.9*	$\pi^+\pi^0$	(21.16±0.15)%	205
		m^2=0.24371	$c\tau$=370.9	$\pi^+\pi^+\pi^-$	(5.59±0.03)% S=1.1*	125
			$(\tau^+-\tau^-)/\bar\tau$=	$\pi^+\pi^0\pi^0$	(1.73±0.05)% S=1.3*	133
			(.11±.09)%	$\mu^+\nu\pi^0$	(3.20±0.09)% S=1.7*	215
			(test of CPT)	$e^+\nu\pi^0$	(4.82±0.05)% S=1.1*	228
			S=1.2*	$\mu^+\nu\gamma$	[e](5.8 ±3.5)$\times10^{-3}$	236
				$e^+\nu\pi^0\pi^0$	(1.8 $^{+2.4}_{-0.6}$)$\times10^{-5}$	207
		$m_{K^\pm}-m_{K^0}$=−4.01		$e^+\nu\pi^+\pi^-$	(3.90±0.15)$\times10^{-5}$	203
		±0.13		$e^-\bar\nu\pi^+\pi^+$	(<5)$\times10^{-7}$	203
		S=1.1*		$\mu^+\nu\pi^+\pi^-$	(0.9 ±0.4)$\times10^{-5}$	151
				$\mu^-\bar\nu\pi^+\pi^+$	(<3.0)$\times10^{-6}$	151
				$e^+\nu$	(1.54±0.09)$\times10^{-5}$	247
				$e^+\nu\gamma$ (SD+)[i]	(1.52±0.23)$\times10^{-5}$	247
				$e^+\nu\gamma$ (SD−)[i]	(<1.0)$\times10^{-4}$	247
				$\pi^+\pi^0\gamma$	[j,e](2.75±0.16)$\times10^{-4}$	205
				$\pi^+\pi^+\pi^-\gamma$	[e](1.0 ±0.4)$\times10^{-4}$	125
				$\mu^+\nu\pi^0\gamma$	[e](<6)$\times10^{-5}$	215
				$e^+\nu\pi^0\gamma$	[e](3.7 ±1.4)$\times10^{-4}$	228
				$e^+e^-\pi^+$	(2.6 ±0.5)$\times10^{-7}$	227
				$e^+e^+\pi^-$	(<1)$\times10^{-8}$	227
				$\mu^+\mu^-\pi^+$	(<2.4)$\times10^{-6}$	172
				$\pi^+\gamma\gamma$	[e](<3.5)$\times10^{-5}$	227
				$\pi^+\gamma\gamma\gamma$	[e](<3.0)$\times10^{-4}$	227
				$\pi^+\nu\bar\nu$	(<0.6)$\times10^{-6}$	227
				$\pi^+\gamma$	(<4)$\times10^{-6}$	227
				$e^+\mu^\pm\pi^\mp$	(<7)$\times10^{-9}$	214
				$e^-\mu^+\pi^+$	(<5)$\times10^{-9}$	214
				$e^+\nu\nu\bar\nu$	(<6)$\times10^{-5}$	247
				$\mu^+\nu\nu\bar\nu$	(<6)$\times10^{-6}$	236
				$\mu^+\nu e^+e^-$	(11 ±3)$\times10^{-7}$	236
				$\mu^-\nu e^+e^+$	(<2.0)$\times10^{-8}$	236
				$e^+\nu e^+e^-$	(2 $^{+2}_{-1}$)$\times10^{-7}$	247
K^0 $\bar K^0$	$\frac{1}{2}(0^-)$	497.67	50% K_{Short}, 50% K_{Long}			
		±0.13				
		S=1.1*				
		m^2=0.24768				
K^0_S	$\frac{1}{2}(0^-)$		0.8923×10^{-10}	$\pi^+\pi^-$	(68.61±0.24)% S=1.1*	206
			±.0022	$\pi^0\pi^0$	(31.39±0.24)% S=1.1*	209
			$c\tau$=2.675	$\mu^+\mu^-$	(<3.2)$\times10^{-7}$	225
				e^+e^-	(<3.4)$\times10^{-4}$	249
				$\pi^+\pi^-\gamma$	[e](1.85±0.10)$\times10^{-3}$	206
				$\gamma\gamma$	(<0.4)$\times10^{-3}$	249
K^0_L	$\frac{1}{2}(0^-)$		5.183×10^{-8}	$\pi^0\pi^0\pi^0$	(21.5 ±0.7)% S=1.3*	139
			±.040	$\pi^+\pi^-\pi^0$	(12.39±0.18)% S=1.2*	133
			$c\tau$=1554	$\pi^\pm\mu^\mp\nu$	(27.0 ±0.5)% S=1.1*	216
				$\pi^\pm e^\mp\nu$ (incl. $\pi e\nu\gamma$)	(38.8 ±0.5)% S=1.1*	229
				$\pi e\nu\gamma$	[e](1.3 ±0.8)%	229
		$m_{K_L}-m_{K_S}$= $0.5349\times10^{10}\hbar$ sec^{-1}		$\pi^+\pi^-$	[k](0.203±0.005)%	206
		±0.0022		$\pi^0\pi^0$	[k](0.094±0.018)% S=1.5*	209
				$\pi^+\pi^-\gamma$	[e](6.0 ±2.0)$\times10^{-5}$	206
				$\pi^0\gamma\gamma$	(<2.4)$\times10^{-4}$	231
				$\gamma\gamma$	(4.9 ±0.5)$\times10^{-4}$	249
				$e\mu$	(<2.0)$\times10^{-9}$	238
				$\mu^+\mu^-$	(9.1 ±1.9)$\times10^{-9}$	225
				$\mu^+\mu^-\gamma$	(<7.8)$\times10^{-6}$	225
				$\mu^+\mu^-\pi^0$	(<5.7)$\times10^{-5}$	177
				e^+e^-	(<2.0)$\times10^{-9}$	249
				$e^+e^-\gamma$	(<2.8)$\times10^{-5}$	249
				$\pi^+\pi^-e^+e^-$	(<8.8)$\times10^{-6}$	206
				$\pi^0\pi^\pm e^\mp\nu$	(<2.2)$\times10^{-3}$	207
			CHARMED MESONS[a]			
				$D^+ \xrightarrow{d}$		
$D^\pm$	$\frac{1}{2}(0^-)$[f]	1868.3[l]	$(2.5^{+3.5}_{-1.5})\times10^{-13}$	K^-anything	(10 ±7)%	
		±0.9		†[$K^-\pi^+\pi^+$(incl. $K^*\pi$)	(3.9 ±1.0)%]	845
		m^2=3.491	$c\tau$=0.007	†[$\bar K^*(892)^0\pi^+$	(seen)]	456
		$m_{D^\pm}-m_{D^0}$=5.0		†[$K^-K^+\pi^+$	(<0.6)%]	743
		±0.8		$\bar K^0$anything	(39 ±29)%	
				†[$\bar K^0\pi^+$	(1.5 ±0.6)%]	862
				$e^\pm$anything	[m](*8.2 ±1.2*)%	
				$\pi^+\pi^+\pi^-$	(<0.31)%	908
				K^+anything	(6 ±6)%	
				$K^+\pi^+\pi^-$	(<0.20)%	845
				$D^0 \xrightarrow{d}$		
D^0 $\bar D^0$	$\frac{1}{2}(0^-)$[f]	1863.1[l]	$(3.5^{+3.5}_{-1.7})\times10^{-13}$	$K^\mp$anything	(35 ±10)%	
		±0.9		†[$K^-\pi^+$	(1.8 ±0.5)%]	860
		m^2=3.471	$c\tau$=0.01	†[$K^-\pi^+\pi^0$	(12 ±6)%]	843
				†[$K^-\pi^+\pi^+\pi^-$	(3.5 ±0.9)%]	812
		$\frac{\Gamma(D^0\to\bar D^0\to K^+\pi^-)}{\Gamma(D^0\to K\pi)}<0.16$		$\bar K^0$anything + K^0any	(57 ±26)%	
				†[$\bar K^0\pi^0$ + $K^0\pi^0$	(<6)%]	859
				†[$\bar K^0\pi^+\pi^-$ + $K^0\pi^+\pi^-$	(4.4 ±1.1)%]	841
				$e^\pm$anything	[m](*8.2 ±1.2*)%	
				$\pi^+\pi^-$	(5.9 ±3.2)$\times10^{-4}$	921
				K^+K^-	(2.0 ±0.8)$\times10^{-3}$	790

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)C_n$ [a]	Mass (MeV) Mass² (GeV)²	Mean life (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
			NONSTRANGE BARYONS [a]			
p	$\frac{1}{2}(\frac{1}{2}^+)$	938.2796	stable ($>10^{30}$y)	stable		
		±0.0027				
		m^2= 0.880369		$\lvert q_p\rvert - \lvert q_e\rvert < 10^{-21}\lvert q_e\rvert$ [n]		
n	$\frac{1}{2}(\frac{1}{2}^+)$	939.5731	917±14	$pe^-\bar{\nu}$	100 %	1
		±0.0027	$c\tau=2.75\times10^{13}$	$p\nu\bar{\nu}$ (chg.noncons.)	(<3)$\times10^{-19}$	1
		m^2= 0.882798				
		m_p-m_n=−1.29343				
		±0.00004		$\lvert q_n\rvert < 10^{-21}\lvert q_e\rvert$ [n]		
			STRANGENESS −1 BARYONS [a]			
Λ	$0(\frac{1}{2}^+)$	1115.60	2.632×10^{-10}	$p\pi^-$	(64.2 ± 0.5)%	100
		±0.05	±.020 S=1.6*	$n\pi^0$	(35.8 ± 0.5)%	104
		S=1.2*	$c\tau$=7.89	$pe^-\nu$	(8.07±0.28)$\times10^{-4}$	163
		m^2= 1.2446		$p\mu^-\nu$	(1.57±0.35)$\times10^{-4}$	131
		$m_\Lambda-m_{\Sigma^0}$= −76.86		$p\pi^-\gamma$	[e](0.85±0.14)$\times10^{-3}$	100
		±0.08				
Σ^+	$1(\frac{1}{2}^+)$	1189.36	0.800×10^{-10}	$p\pi^0$	(51.64±0.30)%	189
		±0.06	±.004	$n\pi^+$	(48.36±0.30)%	185
		S=1.8*	$c\tau$=2.40	$p\gamma$	(1.24±0.18)$\times10^{-3}$ S=1.4*	225
		m^2= 1.4146		$n\pi^+\gamma$	[e](0.93±0.10)$\times10^{-3}$	185
				$\Lambda e^+\nu$	(2.02±0.47)$\times10^{-5}$	71
		$m_{\Sigma^+}-m_{\Sigma^-}$= −7.98	$\frac{\Gamma(\Sigma^+\to\ell^+n\nu)}{\Gamma(\Sigma^-\to\ell^-n\nu)}$<.04 ←	$n\mu^+\nu$	(<3.0)$\times10^{-5}$	202
		±.08		$ne^+\nu$	(<0.5)$\times10^{-5}$	224
		S=1.2*		pe^+e^-	(<7)$\times10^{-6}$	225
Σ^0	$1(\frac{1}{2}^+)$[p]	1192.46	5.8×10^{-20}	$\Lambda\gamma$	100 %	74
		±0.08	±1.3	Λe^+e^-	[g](5.45)$\times10^{-3}$	74
		m^2= 1.4220	$c\tau=1.7\times10^{-9}$	$\Lambda\gamma\gamma$	(<3)%	74
Σ^-	$1(\frac{1}{2}^+)$	1197.34	1.482×10^{-10}	$n\pi^-$	100 %	193
		±0.05	±.011 S=1.3*	$ne^-\nu$	(1.08±0.04)$\times10^{-3}$	230
		m^2= 1.4336	$c\tau$=4.44	$n\mu^-\nu$	(0.45±0.04)$\times10^{-3}$	210
				$\Lambda e^-\nu$	(0.61±0.05)$\times10^{-4}$	79
		$m_{\Sigma^0}-m_{\Sigma^-}$= −4.88		$n\pi^-\gamma$	[e](4.6 ±0.6)$\times10^{-4}$	193
		±.06				
			STRANGENESS −2 BARYONS [a]			
Ξ^0	$\frac{1}{2}(\frac{1}{2}^+)$[q]	1314.9	2.90×10^{-10}	$\Lambda\pi^0$	100 %	135
		±0.6	±.10	$\Lambda\gamma$	(0.5 ±0.5)%	184
		m^2= 1.7290	$c\tau$=8.69	$\Sigma^0\gamma$	(<7)%	117
				$p\pi^-$	(<3.6)$\times10^{-5}$	299
				$pe^-\nu$	(<1.3)$\times10^{-3}$	323
				$\Sigma^+e^-\nu$	(<1.1)$\times10^{-3}$	120
				$\Sigma^-e^+\nu$	(<0.9)$\times10^{-3}$	112
		$m_{\Xi^0}-m_{\Xi^-}$=−6.4		$\Sigma^+\mu^-\nu$	(<1.1)$\times10^{-3}$	64
		±.6		$\Sigma^-\mu^+\nu$	(<0.9)$\times10^{-3}$	49
				$p\mu^-\nu$	(<1.3)$\times10^{-3}$	309
Ξ^-	$\frac{1}{2}(\frac{1}{2}^+)$[q]	1321.32	1.641×10^{-10}	$\Lambda\pi^-$	100 %	139
		±0.13	±.016	$\Lambda e^-\nu$	(*2.8 ±1.2*)$\times10^{-4}$	190
		m^2= 1.7459	$c\tau$=4.92	$\Sigma^0e^-\nu$	(<5)$\times10^{-4}$	123
				$\Lambda\mu^-\nu$	(3.1 ±1.2)$\times10^{-4}$	163
				$\Sigma^0\mu^-\nu$	(<8)$\times10^{-4}$	70
				$n\pi^-$	(<1.1)$\times10^{-3}$	303
				$ne^-\nu$	(<3.2)$\times10^{-3}$	327
				$n\mu^-\nu$	(<1.5)%	313
				$\Sigma^-\gamma$	(<1.2)$\times10^{-3}$	118
				$p\pi^-\pi^-$	(<4)$\times10^{-4}$	223
				$p\pi^-e^-\nu$	(<4)$\times10^{-4}$	304
				$p\pi^-\mu^-\nu$	(<4)$\times10^{-4}$	250
				$\Xi^0e^-\nu$	(<2.3)$\times10^{-3}$	6
			STRANGENESS −3 BARYON [a]			
Ω^-	$0(\frac{3}{2}^+)$[q]	1672.22	0.82×10^{-10}	ΛK^-	(68.6 ±1.3)%	211
		±.31	±.03	$\Xi^0\pi^-$	(23.4 ±1.3)%	293
		m^2= 2.7963	$c\tau$=2.5	$\Xi^-\pi^0$	(8.0 ±0.8)%	290
				$\Xi^0e^-\nu$	(~1)%	319
				$\Xi(1530)^0\pi^-$	(~2)$\times10^{-3}$	15
				$\Lambda\pi^-$	(<1.3)$\times10^{-3}$	449
				$\Xi^-\gamma$	(<3.1)$\times10^{-3}$	314
			NONSTRANGE CHARMED BARYON [a]			
Λ_c^+	$0(\frac{1}{2}^+)$[r]	2273	$\sim7\times10^{-13}$	$\Lambda\pi^+\pi^+\pi^-$	(seen)	798
		±6	$c\tau\sim0.02$	$pK^-\pi^+$	(2.2 ±1.0)%	814
→		S=1.6*		$pK^*(892)^0$	(seen)	567
→		m^2= 5.17		$\Delta(1232)^{++}K^-$	(seen)	700

→
→
→
→
→

ADDENDUM TO

Stable Particle Table

	Magnetic moment	
e	$1.001\ 159\ 652\ 41 \pm .000\ 000\ 000\ 20$	$\frac{e\hbar}{2m_e c}$
μ	$1.001\ 165\ 924 \pm .000\ 000\ 009$	$\frac{e\hbar}{2m_\mu c}$

μ Decay parameters [s]

$\rho = 0.752 \pm 0.003$ $\eta = -0.12 \pm 0.21$

$\xi = 0.972 \pm 0.013$ $\delta = 0.755 \pm 0.009$ $h = 1.00 \pm 0.13$

$|g_A/g_V| = 0.86^{+0.33}_{-0.11}$ $\phi = 180° \pm 15°$

η Mode	Left–right asymmetry	Sextant asymmetry	Quadrant asymmetry
$\pi^+\pi^-\pi^0$	$(0.12 \pm .17)\%$	$(0.19 \pm 0.16)\%$	$(-0.17 \pm 0.17)\%$
$\pi^+\pi^-\gamma$	$(0.88 \pm .40)\%$		$\beta = 0.047 \pm 0.062$

	Mode	Partial rate (sec^{-1})	
$K^\pm$	$\mu\nu$	$(51.33 \pm 0.17) \times 10^6$	$S=1.2^*$
	$\pi\pi^0$	$(17.10 \pm 0.13) \times 10^6$	$S=1.1^*$
	$\pi\pi^+\pi^-$	$(4.52 \pm 0.02) \times 10^6$	$S=1.1^*$
	$\pi\pi^0\pi^0$	$(1.40 \pm 0.04) \times 10^6$	$S=1.3^*$
	$\mu\pi^0\nu$	$(2.58 \pm 0.07) \times 10^6$	$S=1.7^*$
	$e\pi^0\nu$	$(3.90 \pm 0.04) \times 10^6$	$S=1.1^*$
K^0_S	$\pi^+\pi^-$	$^k(0.7689 \pm .0033) \times 10^{10}$	
	$\pi^0\pi^0$	$^k(0.3517 \pm .0029) \times 10^{10}$	$S=1.1^*$
K^0_L	$\pi^0\pi^0\pi^0$	$(4.14 \pm 0.15) \times 10^6$	$S=1.3^*$
	$\pi^+\pi^-\pi^0$	$(2.39 \pm 0.04) \times 10^6$	$S=1.2^*$
	$\pi\mu\nu$	$(5.21 \pm 0.10) \times 10^6$	$S=1.1^*$
	$\pi e\nu$	$(7.49 \pm 0.11) \times 10^6$	$S=1.1^*$
	$\pi^+\pi^-$	$^k(3.91 \pm 0.10) \times 10^4$	
	$\pi^0\pi^0$	$^k(1.81 \pm 0.35) \times 10^4$	$S=1.5^*$

Slope parameters for $K \to 3\pi$ [t]

$K^+ \to \pi^+\pi^+\pi^-$	$g = -0.215 \pm .004$	$S=1.4^*$
$K^- \to \pi^-\pi^-\pi^+$	$g = -0.217 \pm .007$	$S=2.5^*$
$K^\pm \to \pi^0\pi^0\pi^\pm$	$g = 0.607 \pm .030$	$S=1.3^*$
$K^0_L \to \pi^+\pi^-\pi^0$	$g = 0.670 \pm .014$	$S=1.6^*$

See Data Card Listings for quadratic coefficients.

$K^+_{\ell 3}$	$\lambda^e_+ = 0.029 \pm .004$		$K^0_{\ell 3}$	$\lambda^e_+ = 0.0301 \pm .0016$	$S=1.2^*$
	$\lambda^\mu_+ = 0.026 \pm .008$	$S=1.5^*$		$\lambda^\mu_+ = 0.034 \pm .006$	$S=2.5^*$
	$\lambda^\mu_0 = -0.003 \pm .007$	$S=1.5^*$		$\lambda^\mu_0 = 0.020 \pm .007$	$S=2.5^*$

See Data Card Listings for ξ, f_s, and f_t.

CP violation parameters [u,k]

$|\eta_{+-}| = (2.274 \pm .022) \times 10^{-3}$ $|\eta_{00}| = (2.33 \pm .08) \times 10^{-3}$ $S=1.1^*$

$\phi_{+-} = (44.6 \pm 1.2)°$ $\phi_{00} = (54 \pm 5)°$

$|\eta_{+-0}|^2 < 0.12$ $|\eta_{000}|^2 < 0.28$ $\delta = (0.330 \pm .012) \times 10^{-2}$

$\Delta S = -\Delta Q$

Re $x = 0.009 \pm .020$ $S=1.4^*$ Im $x = -0.004 \pm .026$ $S=1.1^*$

	Magnetic moment ($e\hbar/2m_pc$)	Mode	Decay parameters [v] Measured α	Measured ϕ(degree)	Derived γ	Derived Δ(degree)	g_A/g_V	g_V/g_A
p	$2.7928456 \pm .0000011$							
n [w]	$-1.91304184 \pm .00000088$	$pe^-\nu$					-1.254 ± 0.007 $\delta = (180.11 \pm 0.17)°$	
Λ [w]	$-0.614 \pm .005$	$p\pi^-$	0.642 ± 0.013	$(-6.5 \pm 3.5)°$	0.76	$(7.7^{+4.0}_{-4.1})°$		
		$n\pi^0$	0.646 ± 0.044					
		$pe\nu$					-0.62 ± 0.05 $S=1.2^*$	
Σ^+	*2.33* *±.13*	$p\pi^0$	-0.979 ± 0.016	$(36 \pm 34)°$	0.17	$(187 \pm 6)°$		
		$n\pi^+$	$+0.068 \pm 0.013$	$(167 \pm 20)°$	-0.97	$(-72^{+132}_{-11})°$		
		$p\gamma$	$-1.03^{+0.52}_{-0.42}$	$S=1.1^*$				
Σ^-	$-1.41 \pm .25$	$n\pi^-$	-0.068 ± 0.008	$(10 \pm 15)°$	0.98	$(249^{+12}_{-115})°$		
		$ne^-\nu$					$\pm(0.385 \pm 0.070)$ $S=2.3^*$	
		$\Lambda e^-\nu$						0.10 ± 0.22 $S=1.5^*$
Ξ^0	$-1.20 \pm .06$	$\Lambda\pi^0$	-0.47 ± 0.05 $S=1.3^*$	$(21 \pm 12)°$	0.84	$(216^{+13}_{-19})°$		
Ξ^-	$-1.85 \pm .75$	$\Lambda\pi^-$	-0.403 ± 0.017	$(2 \pm 6)°$ $S=1.1^*$	0.92	$(185 \pm 13)°$		
Ω^-		ΛK^-	*−0.26±0.33* $S=1.5^*$					

Stable Particle Table *(cont'd)*

→ Indicates an entry in the Stable Particle Data Card Listings not entered in the Stable Particle Table. This is the case for ν_τ, for the charmed-strange meson $F^\pm$, and for listings of searches for heavy leptons other than $\tau^\pm$, intermediate boson searches, quark searches, magnetic monopole searches, charm seaches, and other particle searches.

* S = Scale factor = $\sqrt{\chi^2/(N-1)}$, where N ≈ number of experiments. S should be ≈ 1. If S > 1, we have enlarged the error of the mean, $\delta\bar{x}$; i.e., $\delta\bar{x} \to S\delta\bar{x}$. This convention is still inadequate, since if S >> 1 the experiments are probably inconsistent, and therefore the real uncertainty is probably even greater than $S\delta x$. See text, and ideograms in Stable Particle Data Card Listings.

† Square brackets indicate a subreaction of the previous (unbracketed) decay mode.

a. The baryon number B, strangeness S, and charm C of the hadrons which appear in the tables are as follows:

Mesons (B=0)	S	C	Baryons (B=1)	S	C
π,η	0	0	p,n	0	0
K^+,K^0	+1	0	Λ,Σ	−1	0
$K^-,\bar{K}^0$	−1	0	Ξ	−2	0
D^+,D^0	0	+1	Ω^-	−3	0
$D^-,\bar{D}^0$	0	−1	Λ_c^+	0	+1

b. Quoted upper limits correspond to a 90% confidence level.

c. In decays with more than two bodies, p_{max} is the maximum momentum that any particle can have.

d. For simplicity, decay mode charge states are written for the particle shown. For antiparticle modes all particles must be charge conjugated.

e. See Stable Particle Data Card Listings for energy limits used in this measurement.

f. Quantum numbers shown are favored but not yet established. See Data Card Listings.

g. Theoretical value; see also Stable Particle Data Card Listings.

h. See note in Stable Particle Data Card Listings.

i. Structure-dependent part with positive (SD+) and negative (SD−) photon helicity.

j. The direct emission branching fraction is $(1.56\pm.35)\times10^{-5}$.

k. The $K_S^0 \to \pi\pi$ and $K_L^0 \to \pi\pi$ rates (and branching fractions) are from independent fits and do not include results of K_L^0–K_S^0 interference experiments. The $|\eta_{+-}|$ and $|\eta_{00}|$ values given in the addendum are these rates combined with the $|\eta_{+-}|$ and $|\eta_{00}|$ results from interference experiments.

ℓ. Error does not include 0.13% uncertainty in the absolute SPEAR energy calibration. Assumes m_ψ=3095 MeV.

m. This is a weighted average of $D^\pm$ (44%) and D^0 (56%) branching fractions.

n. Limit from neutrality-of-matter experiments. Assumes $|q_n|=|q_p|-|q_e|$.

p. J^P not measured for Σ^0. Assumed same as $\Sigma^\pm$ to allow isotriplet association.

q. P for Ξ and J^P for Ω^- not yet measured. Values shown are SU(3) predictions.

r. J^P for Λ_c^+ not yet measured. Values shown are SU(4) predictions.

s. $|g_A/g_V|$ defined by $g_A^2 = |C_A|^2+|C'_A|^2$, $g_V^2 = |C_V|^2+|C'_V|^2$, and $\Sigma\langle\bar{e}|\Gamma_i|\mu\rangle\langle\bar{\nu}|\Gamma_i(C_i+C'_i\gamma_5)|\nu\rangle$; ϕ defined by $\cos\phi = -\mathrm{Re}(C_A^* C'_V + C'_A C_V^*)/g_A g_V$ [for more details, see text Section VI A].

t. The definition of the slope parameter of the Dalitz plot is as follows [see also text Section VI B.1]:

$$|M|^2 = 1 + g\left(\frac{s_3-s_0}{m_{\pi^+}^2}\right).$$

u. The definition for the CP violation parameters is as follows [see also text Section VI B.3]:

$$\eta_{+-} = |\eta_{+-}|e^{i\phi_{+-}} = \frac{A(K_L^0\to\pi^+\pi^-)}{A(K_S^0\to\pi^+\pi^-)} \qquad \eta_{00} = |\eta_{00}|e^{i\phi_{00}} = \frac{A(K_L^0\to\pi^0\pi^0)}{A(K_S^0\to\pi^0\pi^0)}$$

$$\delta = \frac{\Gamma(K_L^0\to\ell^+)-\Gamma(K_L^0\to\ell^-)}{\Gamma(K_L^0\to\ell^+)+\Gamma(K_L^0\to\ell^-)}, \quad |\eta_{+-0}|^2 = \frac{\Gamma(K_S^0\to\pi^+\pi^-\pi^0)^{\text{CP viol.}}}{\Gamma(K_L^0\to\pi^+\pi^-\pi^0)}, \quad |\eta_{000}|^2 = \frac{\Gamma(K_S^0\to\pi^0\pi^0\pi^0)^{\text{CP viol.}}}{\Gamma(K_L^0\to\pi^0\pi^0\pi^0)}.$$

v. The definition of these quantites is as follows [for more details on sign convention, see text Section VI B]:

$$\alpha = \frac{2|s||p|\cos\Delta}{|s|^2+|p|^2} \qquad \beta = \sqrt{1-\alpha^2}\sin\phi \qquad g_A/g_V \text{ defined by } \langle B_f|\gamma_\lambda(g_V-g_A\gamma_5)|B_i\rangle$$

$$\beta = \frac{-2|s||p|\sin\Delta}{|s|^2+|p|^2} \qquad \gamma = \sqrt{1-\alpha^2}\cos\phi \qquad \delta \text{ defined by } g_A/g_V = |g_A/g_V|e^{i\delta}$$

w. For limits on electric dipole moment of n and Λ, see Data Card Listings.

Meson Table

April 1980

In addition to the entries in the Meson Table, the Meson Data Card Listings contain all substantial claims for meson resonances. See Contents of Meson Data Card Listings below.

Quantities in italics are new or have changed by more than one (old) standard deviation since April 1978.

Name	$I^G(J^P)C_n$ ⊢estab.	Mass M (MeV)	Full Width Γ (MeV)	M^2 $\pm\Gamma M^{(a)}$ $(GeV)^2$	Partial decay mode: Mode	Fraction (%) [Upper limits are 1σ (%)]	p or p_{max}[b] (MeV/c)
NONSTRANGE MESONS							
$\pi^\pm$	$1^-(0^-)+$	139.57	0.0	0.019479	See Stable Particle Table		
π^0		134.96	7.95 eV ±.55 eV	0.018215			
η	$0^+(0^-)+$	548.8 ±0.6	0.85 keV ±.12 keV	0.301 ±.000	Neutral	71.0 See Stable	
					Charged	29.0 Particle Table	
ρ(770)	$1^+(1^-)-$	776¶ ±3§	158¶ ±5§	0.602 ±.123	$\pi\pi$	≈ 100	362
					$\pi\gamma$	0.024 ±.007	375
					e^+e^-	0.0043±.0005 (d)	388
					$\mu^+\mu^-$	0.0067±.0012 (d)	373
					$\eta\gamma$	seen¶	194
M and Γ from neutral mode.					For upper limits, see footnote (e)		
ω(783)	$0^-(1^-)-$	782.4 ±0.2 S=1.1*	10.1 ±.3	0.612 ±.008	$\pi^+\pi^-\pi^0$	89.8±0.5	327
					$\pi^+\pi^-$	1.4±0.2	365
					$\pi^0\gamma$	8.8±0.5	380
					e^+e^-	0.0076±.0017 S=1.9*	391
					$\eta\gamma$	seen¶	199
					For upper limits, see footnote (f)		
η′(958)	$0^+(0^-)+$¶	957.57 ±0.25	0.28 ±0.10	0.917 ±.0003	$\eta\pi\pi$	65.6±1.6	231
					$\rho^0\gamma$	29.8±1.6	164
					$\omega\gamma$	2.7±0.5	159
					$\gamma\gamma$	1.9±0.2	479
					For upper limits, see footnote (g)		
δ(980)	$1^-(0^+)+$	981(h) ±3	52(h) ±8	0.962 ±.051	$\eta\pi$	seen	319
					$K\bar{K}$	seen¶	
S*(980)	$0^+(0^+)+$	∿ 980(c)§ ±10§	40(c)§ ±10§	0.960 ±.039	$K\bar{K}$	seen¶	
					$\pi\pi$	seen	470
See note on ππ and $K\bar{K}$ S-wave¶.							
Φ(1020)	$0^-(1^-)-$	1019.6 ±0.1 S=1.3*	4.1 ±.2	1.040 ±.004	K^+K^-	48.6±1.2 S=1.3*	127
					K_LK_S	35.2±1.2 S=1.5*	111
					$\pi^+\pi^-\pi^0$ (incl. ρπ)	14.7±0.7 S=1.2*	462
					$\eta\gamma$	1.5±0.2	362
					$\pi^0\gamma$	0.14±0.05	501
					e^+e^-	.031±.001 S=1.1*	510
					$\mu^+\mu^-$	.025±.003	499
					For upper limits, see footnote (i)		
A_1(1100-1300)	$1^-(1^+)+$	1100¶ to 1300	∿ 300¶	1.44 ±.36	ρπ	*dominant*	329
					$\pi(\pi\pi)_{S\text{-wave}}$	*seen*	558
B(1235)	$1^+(1^+)-$	1231 ±10§	129 ±10§	1.52 ±.16	ωπ	only mode seen	348
					[D/S amplitude ratio = .29±.05]		
					For upper limits, see footnote (j)		
f(1270)	$0^+(2^+)+$	1273 ±5§	178 ±20§	1.62 ±.23	$\pi\pi$	*83.1±1.9* S = 1.4*	621
					$2\pi^+2\pi^-$	2.9±0.3 S = 1.1*	558
					$K\bar{K}$	2.8±0.3 S = 1.3*	397
					$\pi^+\pi^-2\pi^0$	seen	561
					For upper limits, see footnote (ℓ)		
D(1285)	$0^+(1^+)+$	1284 *±10*§	27 ±10§	1.65 ±.03	$K\bar{K}\pi$	*10±2*	303
					$\eta\pi\pi$	*49±6*	483
					†[δπ	*36±7*]	239
					4π (prob. ρππ)	*41±13*	564
ε(1300)	$0^+(0^+)+$	∿ 1300	200-400		$\pi\pi$	*∿ 90*	635
					$K\bar{K}$	*∿ 10*	423
See note on ππ and $K\bar{K}$ S wave¶.							
A_2(1310)	$1^-(2^+)+$	1317§ ±5§	102§ ±5§	1.73 ±.13	ρπ	70.0±2.2	414
					ηπ	14.6±1.1	534
					ωππ	10.6±2.5	360
					$\bar{K}K$	4.8±0.5	434
					η′π	<1	285
					πγ	0.45±0.11	651

Meson Table *(cont'd)*

Name	$I^G(J^P)C_n$ ⊢ estab.	Mass M (MeV)	Full Width Γ (MeV)	M^2 $\pm\Gamma M$[a] $(GeV)^2$	Partial decay mode: Mode	Partial decay mode: Fraction (%) [Upper limits are 1σ (%)]	p or p_{max}[b] (MeV/c)
E(1420)	$\underline{0^+(1^+)+}$	1418 ±10§	50§ ±10§	2.01 ±.07	$K\bar{K}\pi$ (prob. $K^*\bar{K}+\bar{K}^*K$)	seen	423
					$\eta\pi\pi$	possibly seen	565
					†[$\delta\pi$	possibly seen]	350
f′(1515)	$\underline{0^+(2^+)+}$	1516 ±12§	67 ±10§	2.30 ±.10	$K\bar{K}$	dominant	572
					$\pi\pi$	seen	745
					For upper limits, see footnote (k)		
ρ′(1600)	$\underline{1^+(1^-)-}$	∼ 1600¶	∼ 300¶	2.56 ±.48	4π (incl. $\rho\pi^+\pi^-$)	∼ 85	738
					$\pi\pi$	∼ 15	788
A_3(1660)	$\underline{1^-(2^-)+}$	*1660*§ *±10*§	*200*§ *±50*§	2.76 ±.33	$f\pi$	∼ *60*	320
					$\rho\pi$	∼ *30*	640
					$\pi(\pi\pi)_{S\text{-wave}}$	∼ *10*	802
ω(1670)	$\underline{0^-(3^-)-}$	1666 ±5	166 ±15§	2.78 ±.28	$\rho\pi$	seen	644
					3π	possibly seen	805
					5π	seen	739
					†[$\omega\pi\pi$ (prob. $B\pi$)	seen]	614
g(1700)¶	$\underline{1^+(3^-)-}$	1700§ ±20§	200§ ±20§	2.89 ±.34	2π	24.0±1.3	838
					4π (incl. $\pi\pi\rho$, $\rho\rho$, $A_2\pi$, $\omega\pi$)	*72.1±1.6*	792
					$K\bar{K}\pi$ (incl. $K^*\bar{K}$)	*2.4±0.7*	631
					$K\bar{K}$	*1.5±0.3*	689
J^P, M and Γ from the 2π and $K\bar{K}$ modes.							
S(1935)¶		1936 ±5§		3.74	$N\bar{N}$	seen	236
Not a well established resonance.¶							
h(2040)	$\underline{0^+(4^+)+}$	2040§ ±20§	150§ ±50§	4.16 ±.31	$\pi\pi$	seen	1010
					$K\bar{K}$	seen	890
J/ψ(3100)	$\underline{0^-(1^-)-}$	3097±1	0.063±0.009	9.598 ±.000	e^+e^-	7±1	1549
					$\mu^+\mu^-$	7±1	1545
					hadrons	86±2	
					†[all stables		
					$2(\pi^+\pi^-)\pi^0$	3.7±0.5	1496
					$3(\pi^+\pi^-)\pi^0$	2.9±0.7	1433
					$\pi^+\pi^-\pi^0K^+K^-$	1.2±0.3	1368
					$\pi^+\pi^-K^+K^-$	*0.72±0.23*	1407
					$4(\pi^+\pi^-)\pi^0$	0.9±0.3	1345
					$p\bar{p}\pi^+\pi^-$	*0.55±0.06*	1107
					$2(\pi^+\pi^-)$	0.4±0.1	1517
					$3(\pi^+\pi^-)$	0.4±0.2	1466
					$\Xi\bar{\Xi}$	*0.32±0.08*	818
					$2(\pi^+\pi^-)K^+K^-$	0.31±0.13	1320
					$K_S^0K^\pm\pi^\mp$	0.26±0.07	1440
					$p\bar{p}\eta$	0.23±0.04	948
					$p\bar{n}\pi^-$ or $\bar{p}n\pi^+$	*0.21±0.02*	1174
					$p\bar{p}$	0.22±0.02	1232
					$n\bar{n}$	*0.18±0.09*	1231
					$p\bar{p}\pi^+\pi^-\pi^0$	*0.16±0.06* (n)	1033
					$\Sigma^0\bar{\Sigma}^0$	*0.13±0.04*	988
					$\Lambda\bar{\Lambda}$	0.11±0.02	1074
					$p\bar{p}\pi^0$	0.11±0.01]	1176
					†[with resonances		
					$\rho\pi$	1.2±0.1	1448
					$\omega2\pi^+2\pi^-$	*0.85±0.34*	1392
					ρA_2	*0.84±0.45*	1124
					$\omega\pi\pi$	*0.68±0.19*	1435
					$K^{*0}(892)\bar{K}^{*0}(1430)$	0.67±0.26	1007
					$K\bar{K}^*+\bar{K}K^*$	0.61±0.08	1373
					$B^\pm(1235)\pi^\mp$	*0.29±0.07*	1300
					ωf	*0.23±0.08* S=1.2*	1144
					$\phi\pi^+\pi^-$	0.21±0.09	1365
					$\eta' p\bar{p}$	*0.18±0.06*	596
					$\phi K\bar{K}$	0.18±0.08	1176
					$\omega p\bar{p}$	*0.16±0.03*	768
					$\omega K\bar{K}$	*0.16±0.10*	1265
					$\phi\eta$	0.10±0.06]	1320
					†[radiative decays		
					$\gamma\eta'$	0.25±0.06	1400
					γf	0.15±0.05]	1287
					For smaller branching ratios and upper limits see listing.¶		

Meson Table *(cont'd)*

Name	$I^G(J^P)C_n$ (estab.)	Mass M (MeV)	Full Width Γ (MeV)	M^2 $\pm\Gamma M$[a] $(GeV)^2$	Partial decay mode: Mode	Fraction (%) [Upper limits are 1σ (%)]		p or p_{max}[b] (MeV/c)
χ(3415)	$0^+(0^+)+$	3414±4		11.655	$2(\pi^+\pi^-)$ (incl. $\pi\pi\rho$)	4.6±0.9		1678
					$\pi^+\pi^-K^+K^-$ (incl. $\pi K\bar{K}^*$)	3.7±0.9		1580
					$\gamma J/\psi(3100)$	2.7±1.0 (m)		302
					$3(\pi^+\pi^-)$	1.9±0.7		1632
					$\pi^+\pi^-$	0.9±0.2		1701
					K^+K^-	0.9±0.2		1634
					$p\bar{p}\pi^+\pi^-$	0.6±0.2		1319
P_c or χ(3510)	$0^+(A)+$	3507±4		12.299	$\gamma J/\psi(3100)$	31.5±5.2	S = 1.3*	386
					$3(\pi^+\pi^-)$	2.7±1.1		1681
					$2(\pi^+\pi^-)$ (incl. $\pi\pi\rho$)	2.0±0.6		1726
					$\pi^+\pi^-K^+K^-$ (incl. $\pi K\bar{K}^*$)	1.1±0.4		1630
					$\pi^+\pi^-p\bar{p}$	0.17±0.11		1379
$J^P = 1^+$ preferred.								
χ(3550)	$0^+(N)+$	3551±5		12.610	$\gamma J/\psi(3100)$	15.4±2.4		425
					$2(\pi^+\pi^-)$ (incl. $\pi\pi\rho$)	2.4±0.6		1748
					$\pi^+\pi^-K^+K^-$ (incl. $\pi K\bar{K}^*$)	2.1±0.6		1654
					$3(\pi^+\pi^-)$	1.3±0.8		1704
					$\pi^+\pi^-$ and K^+K^-	0.27±0.11		
					$\pi^+\pi^-p\bar{p}$	0.37±0.14		1407
$J^P = 2^+$ preferred.								
ψ(3685)	$0^-(1^-)-$	3685±1 S=1.1*	0.215±0.040	13.579 ±.001	e^+e^-	0.9±0.1		1842
					$\mu^+\mu^-$	0.8±0.2		1839
					hadrons	98.1±0.3		
					†[$J/\psi\ \pi^+\pi^-$	33±2]		476
	$m_{\psi(3685)} - m_{\psi(3100)}$	= 588.2±0.9 S=1.2*			†[$J/\psi\ \pi^0\pi^0$	17±2]		480
					†[$J/\psi\ \eta$	3.7±0.4]		194
					†[$2(\pi^+\pi^-)\pi^0$	0.4±0.2]		1798
					†[$\pi^+\pi^-K^+K^-$	0.16±0.04]		1725
					†[$p\bar{p}\pi^+\pi^-$	*0.08±0.02*]		1490
					†[$2(\pi^+\pi^-)$	*0.05±0.01*]		1816
					†[γ χ(3415)	7±2]		261
					†[γ χ(3510)	7±2]		174
					†[γ χ(3550)	7±2]		132
					For smaller branching ratios and upper limits see Listings.¶			
ψ(3770)	$(1^-)-$	3768 ±3	25 ±3	14.198 ±.094	e^+e^-	0.0013±0.0002		1884
					$D\bar{D}$	dominant		243
	$m_{\psi(3770)} - m_{\psi(3685)}$	= *82.5±3.7* S=2.2*						
ψ(4030)	$(1^-)-$	*4030*§*±5*§	*52±10*	*16.241 ±0.210*	e^+e^-	*0.0014±0.0004*		2015
					hadrons	*dominant*		
ψ(4160)	$(1^-)-$	*4159±20*	*78±20*	*17.297 ±0.324*	e^+e^-	*0.0010±0.0004*		2079
					hadrons	*dominant*		
ψ(4415)	$(1^-)-$	4415±6	43±20§	19.492 ±.190	e^+e^-	0.0010±0.0003		2207
					hadrons	dominant		
Υ(9460)	$(1^-)-$	*9458±6*	∼ *0.060*	*89.454 ±0.0006*	$\mu^+\mu^-$	*2.2±2.0*		4728
					e^+e^-	*2.5±2.1*		4729
Υ(10020)	$(1^-)-$	*10016±14*	< *12*	*100.320*	$\mu^+\mu^-$	*seen*		5007
					e^+e^-	*seen*		5008
	$m_{\Upsilon(10020)} - m_{\Upsilon(9460)}$	= *559±7*						
Additional structure at m = *10410±30* is seen¶.								
STRANGE MESONS								
K^+ / K^0	$1/2(0^-)$	493.67 / 497.67		0.244 / 0.248	See Stable Particle Table			
$K^*(892)$	$1/2(1^-)$	891.8 ±0.4 S=1.1*	50.3 ±0.8	0.795 ±.045	Kπ	≈ 100		288
					Kππ	< 0.07		216
					Kγ	0.15±0.07		309
M and Γ from charged mode; $m^0 - m^\pm$ = *6.7±1.2* MeV.								
$Q_1(1280)$	$1/2(1^+)$	∼ 1280	∼ 120	1.64 ±.15	Kππ	dominant		501
					†[Kρ	large]		62
					†[$K^*\pi$	possibly seen]		307
					Kω	possibly seen		
$Q_2(1400)$	$1/2(1^+)$	∼ *1400*	∼ *150*	*1.96 ±.21*	Kππ	*dominant*		576
					†[$K^*\pi$	*large*]		399
					†[Kρ	*possibly seen*]		286

Meson Table *(cont'd)*

Name	$I^G(J^P)C_n$ ⊢ estab.	Mass M (MeV)	Full Width Γ (MeV)	M^2 $\pm\Gamma M$[(a)] $(GeV)^2$	Partial decay mode: Mode	Fraction (%) [Upper limits are 1σ (%)]	p or p_{max}[(b)] (MeV/c)
$K^*(1430)$	1/2(2^+)	1434§ ±5§	100§ ±10§	2.06 ±.14	Kπ	49.1±1.6	623
					$K^*\pi$	27.0±2.2	424
					$K^*\pi\pi$	11.2±2.5	374
					Kρ	6.6±1.5 S=1.1*	327
					Kω	3.7±1.6	320
					Kη	2.5±2.6	492
κ(1500)	1/2(0^+)	∿*1500*	∿ *250*	2.25 ±.36	Kπ	seen	661
See note on Kπ S wave¶.							
→→→ L region	1/2	1600 to 2000			Kππ	seen	
Not a well established resonance¶.							
$K^*(1780)$¶	1/2(3^-)	1785 ±6	126§ ±20§	3.19 ±.22	Kππ	large	798
					†[Kρ	large]	619
					†[$K^*\pi$	large]	660
					Kπ	19±5§	817
CHARMED, NONSTRANGE MESONS							
→→ D^+	1/2(0^-)	1868.3		3.491	See Stable Particle Table		
D^0		1863.1		3.471			
$D^{*+}(2010)$	1/2(1^-)	2008.6 ±1.0	< 2.0	4.034	$D^0\pi^+$	64±11	40
					$D^+\pi^0$	*28±9*	37
	$m_{D^{*+}} - m_{D^0}$ = 145.3 ± 0.4 MeV				$D^+\gamma$	*8±7*	135
$D^{*0}(2010)$	1/2(1^-)	2006.0 ±1.5	< 5	4.024	$D^0\pi^0$	55±15	45
					$D^0\gamma$	45±15	138

→→

Meson Table *(cont'd)*

→ Indicates an entry in Meson Data Card Listings not entered in the Meson Table. We do not regard these as established resonances. All the entries in the Listings can be found in the Table of Contents of Meson Data Card Listings.

¶ See Meson Data Card Listings.

* Quoted error includes scale factor $S = \sqrt{\chi^2/(N-1)}$. See footnote to Stable Particle Table.

† Square brackets indicate a subreaction of the previous (unbracketed) decay mode(s).

§ This is only an educated guess; the error given is larger than the error of the average of the published values. (See Meson Data Card Listings for the latter.)

(a) ΓM is approximately the half-width of the resonance when plotted against M^2.

(b) For decay modes into ≥ 3 particles, p_{max} is the maximum momentum that any of the particles in the final state can have. The momenta have been calculated by using the averaged central mass values, without taking into account the widths of the resonances.

(c) From pole position $(M - i\Gamma/2)$.

(d) The e^+e^- branching ratio is from $e^+e^- \to \pi^+\pi^-$ experiments only. The $\omega\rho$ interference is then due to $\omega\rho$ mixing only, and is expected to be small. See note in Meson Data Card Listings. The $\mu^+\mu^-$ branching ratio is compiled from 3 experiments; each possibly with substantial $\omega\rho$ interference. The error reflects this uncertainty; see notes in Meson Data Card Listings. If $e\mu$ universality holds, $\Gamma(\rho^0 \to \mu^+\mu^-) = \Gamma(\rho^0 \to e^+e^-) \times 0.99785$.

(e) Empirical limits on fractions for other decay modes of $\rho(770)$ are $\pi^\pm\eta < 0.8\%$, $\pi^+\pi^+\pi^-\pi^- < 0.15\%$, $\pi^\pm\pi^+\pi^-\pi^0 < 0.2\%$.

(f) Empirical values of fractions for other decay modes of $\omega(783)$ are $\pi^+\pi^-\gamma < 5\%$, $\pi^0\pi^0\gamma < 1\%$, η + neutral(s) $< 1.5\%$, $\mu^+\mu^- < 0.02\%$, $\pi^0\mu^+\mu^- = (9\pm5)\times10^{-5}$

(g) Empirical values of fractions for other decay modes of $\eta'(958)$: $\pi^+\pi^- < 2\%$, $\pi^+\pi^-\pi^0 < 5\%$, $\pi^+\pi^+\pi^-\pi^- < 1\%$, $\pi^+\pi^+\pi^-\pi^-\pi^0 < 1\%$, $6\pi < 1\%$, $\pi^+\pi^-e^+e^- < 0.6\%$, $\pi^0e^+e^- < 1.3\%$, $\eta e^+e^- < 1.1\%$, $\pi^0\rho^0 < 4\%$, $\mu^+\mu^-\gamma = (8\pm4)\times10^{-5}$.

(h) The mass and width are from the $\eta\pi$ mode only. If the $K\bar{K}$ channel is strongly coupled, the width may be larger.

(i) Empirical limits on fractions for other decay modes of $\phi(1020)$ are $\pi^+\pi^- < 0.03\%$, $\pi^+\pi^-\gamma < 0.7\%$, $\omega\gamma < 5\%$, $\rho\gamma < 2\%$, $2\pi^+2\pi^-\pi^0 < 1\%$, $2\pi^+2\pi^- < 0.1\%$.

(j) Empirical limits on fractions for other decay modes of B(1235): $\pi\pi < 15\%$, $K\bar{K} < 2\%$, $4\pi < 50\%$, $\phi\pi < 1.5\%$, $\eta\pi < 25\%$, $(\bar{K}K)^{\pm}\pi^0 < 8\%$, $K_SK_S\,\pi^\pm < 2\%$, $K_SK_L\,\pi^\pm < 6\%$.

(k) Empirical limits on fractions for other decay modes of f'(1515) are $\eta\eta < 50\%$, $\eta\pi\pi < 30\%$, $K\bar{K}\pi + K^*\bar{K} < 35\%$, $2\pi^+2\pi^- < 32\%$.

(ℓ) Empirical limits on fractions for other decay modes of f(1270) are $\eta\pi\pi < 1\%$, $K^0K^-\pi^+$ + c.c. $< 1\%$, $\eta\eta < 2\%$.

(m) Preliminary results from the Crystal Ball experiment give an upper limit of 0.007, see Meson Data Card Listings.

(n) Includes $\rho\bar{p}\pi^+\pi^-\gamma$ and excludes $p\bar{p}\eta$, $p\bar{p}\omega$, $p\bar{p}\eta'$.

Established Nonets, and octet-singlet mixing angles from Appendix IIB, Eq. (2'). Of the two isosinglets, the "mainly octet" one is written first, followed by a semicolon.

$(J^P)C_n$	Nonet members	$\theta_{lin.}$	$\theta_{quadr.}$
$(0^-)+$	π, K, η; η'	-24 ± 1°	-10 ± 1°
$(1^-)-$	ρ, K^*, ϕ; ω	38 ± 1°	40 ± 1°
$(2^+)+$	A_2, K*(1430), f'; f	25 ± 4°	26 ± 4°

Baryon Table

April 1980

The following short list gives the status of all the Baryon States in the Data Card Listings. In addition to the status, the name, the nominal mass, and the quantum numbers (where known) are shown. States with three- or four-star status are included in the main Baryon Table; the others have been omitted because the evidence for the existence of the effect and/or for its interpretation as a resonance is open to considerable question.

N(939) P11 ****	Δ(1232) P33 ****	Λ(1115) P01 ****	Σ(1193) P11 ****	Ξ(1317) P11 ****
N(1470) P11 ****	Δ(1550) P31 **	Λ(1330) Dead	Σ(1385) P13 ****	Ξ(1530) P13 ****
N(1520) D13 ****	Δ(1650) S31 ****	Λ(1405) S01 ****	Σ(1480) *	Ξ(1630) **
N(1535) S11 ****	Δ(1670) D33 ****	Λ(1520) D03 ****	Σ(1560) **	Ξ(1680) S11 **
N(1540) P13 *	Δ(1690) P33 ***	Λ(1600) P01 **	Σ(1580) D13 **	Ξ(1820) 13 ***
N(1650) S11 ****	Δ(1890) F35 ****	Λ(1670) S01 ****	Σ(1620) S11 **	Ξ(1940) **
N(1670) D15 ****	Δ(1900) S31 **	Λ(1690) D03 ****	Σ(1660) P11 ***	Ξ(2030) 1 ***
N(1688) F15 ****	Δ(1910) P31 ****	Λ(1800) S01 ***	Σ(1670) D13 ****	Ξ(2120) *
N(1700) D13 ****	Δ(1950) F37 ****	Λ(1800) P01 **	Σ(1670) **	Ξ(2250) *
N(1710) P11 ****	Δ(1960) P33 **	Λ(1800) G09 *	Σ(1690) **	Ξ(2370) 1 **
N(1810) P13 ****	Δ(1960) D35 ***	Λ(1800) *	Σ(1750) S11 ***	Ξ(2500) **
N(1990) F17 ***	Δ(2160) ***	Λ(1815) F05 ****	Σ(1765) D15 ****	
N(2000) F15 **	Δ(2300) H39 *	Λ(1830) D05 ****	Σ(1770) P11 *	Ω(1672) P03 ****
N(2040) D13 **	Δ(2420) H311***	Λ(1860) P03 ***	Σ(1840) P13 *	
N(2100) S11 *	Δ(2500) G39 *	Λ(2010) *	Σ(1880) P11 **	Λ_c(2260) ***
N(2100) D15 **	Δ(2750) I313*	Λ(2020) F07 *	Σ(1915) F15 ****	
N(2190) G17 ****	Δ(2850) ***	Λ(2100) G07 ****	Σ(1940) D13 ***	Σ_c(2430) **
N(2200) G19 ****	Δ(2950) K315*	Λ(2110) F05 ***	Σ(2000) S11 *	
N(2220) H19 ****	Δ(3230) ***	Λ(2325) D03 *	Σ(2030) F17 ****	
N(2600) I111***		Λ(2350) ****	Σ(2070) F15 *	Dibaryons
N(2700) K113*		Λ(2585) ***	Σ(2080) P13 **	S = 0 *
N(2800) G19 *	Z0(1780) P01 *		Σ(2100) G17 *	S = −1 **
N(3030) ***	Z0(1865) D03 *		Σ(2250) ****	S = −2 *
N(3245) *	Z1(1900) P13 *		Σ(2455) ***	
N(3690) *	Z1(2150) *		Σ(2620) ***	
N(3755) *	Z1(2500) *		Σ(3000) **	
			Σ(3170) *	

**** Good, clear, and unmistakable.
*** Good, but in need of clarification or not absolutely certain.
** Needs confirmation.
* Weak.

[See notes on N's and Δ's, Z*'s, Λ's and Σ's, Ξ*'s, and dibaryons at the beginning of those sections in the Baryon Data Card Listings; also see notes on individual resonances in the Baryon Data Card Listings.]

Particle[a]	I (J^P)[a] — estab.	π or K beam[b] p_{beam} (GeV/c) $\sigma = 4\pi\lambda^2$ (mb)	Mass M[c] (MeV)	Full Width Γ[c] (MeV)	M^2 $\pm\Gamma M$[b] (GeV^2)	Partial decay mode[f]: Mode	Fraction[c] %	p or p_{max}[d] (MeV/c)
S=0 I=1/2 NUCLEON RESONANCES (N)								
p	$1/2(1/2^+)$		938.3		0.880	See Stable Particle Table		
n			939.6		0.883			
N(1470)	$1/2(1/2^+)P'_{11}$	p = 0.66	1400 to	120 to	2.16	$N\pi$	50-65	420
		σ = 27.8	1480	350	±0.29	$N\eta$	~18	*d*
				(200)		$N\pi\pi$	~25	368
						[$N\varepsilon$	~ 7][e]	*d*
						[$\Delta\pi$	~23][e]	177
						[$N\rho$	~ 7][e]	*d*
N(1520)	$1/2(3/2^-)D'_{13}$	p = 0.74	1510 to	100 to	2.31	$N\pi$	~55	456
		σ = 23.5	1530	140	±0.19	$N\pi\pi$	~45	410
				(125)		[$N\varepsilon$	< 5][e]	*d*
						[$N\rho$	~19][e]	*d*
						[$\Delta\pi$	~23][e]	228
						$N\eta$	< 1	*d*
N(1535)	$1/2(1/2^-)S'_{11}$	p = 0.76	1520 to	100 to	2.36	$N\pi$	~40	467
		σ = 22.5	1560	250	±0.23	$N\eta$	~55	182
				(150)		$N\pi\pi$	~ 5	422
						[$N\rho$	~ 3][e]	*d*
						[$N\varepsilon$	~ 2][e]	*d*
						[$\Delta\pi$	~ 1][e]	243
N(1650)	$1/2(1/2^-)S''_{11}$	p = 1.05	1620 to	100 to	2.72	$N\pi$	~60	547
		σ = 14.3	1680	200	±0.25	$N\pi\pi$	~30	511
				(150)		[$N\varepsilon$	<10][e]	*d*
						[$N\rho$	7-21][e]	*d*
						[$\Delta\pi$	4-15][e]	344
						ΛK	~10	161
						ΣK	2-7	*d*
						$N\eta$	~ 1	346

Baryon Table *(cont'd)*

Particle[a]	I (J^P)[a] estab.	π or K beam[b] p_{beam} (GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass M[c] (MeV)	Full Width Γ[c] (MeV)	M^2 $\pm\Gamma M$[b] (GeV^2)	Partial decay mode[f] Mode	Fraction[c] %	p or p_{max}[d] (MeV/c)
N(1670)	$1/2(5/2^-)D'_{15}$	p = 1.00 σ = 15.6	1660 to 1690	120 to 180 (155)	2.79 ±0.26	Nπ	~40	560
						Nππ	~60	525
						[Δπ	~50][e]	360
						[Nρ	~ 5][e]	*d*
						ΛK	< 0.3	200
						Nη	< 0.5	368
N(1688)	$1/2(5/2^+)F'_{15}$	p = 1.03 σ = 14.9	1670 to 1690	110 to 140 (130)	2.85 ±0.22	Nπ	~60	572
						Nππ	~40	538
						[Nε	~22][e]	340
						[Nρ	~13][e]	*d*
						[Δπ	~18][e]	375
						Nη	< 0.3	388
N(1700)	$1/2(3/2^-)D''_{13}$	p = 1.05 σ = 14.3	1670 to 1730	70 to 120[g] (120)	2.89 ±0.20	Nπ	~10	580
						Nππ	~90	547
						[Nε	<40][e]	355
						[Nρ	< 5][e]	*d*
						[Δπ	15-40][e]	385
						ΛK	< 1	250
						Nη	~ 4	400
N(1710)	$1/2(1/2^+)P''_{11}$	p = 1.20 σ = 12.2	1680 to 1740	100 to 140[h] (120)	2.92 ±0.21	Nπ	~20	587
						Nππ	>50	554
						[Nε	15-40][e]	*d*
						[Nρ	40-65][e]	*d*
						[Δπ	10-20][e]	393
						ΛK	< 5	264
						ΣK	~10	138
						Nη	2-20[i]	410
N(1810)	$1/2(3/2^+)P''_{13}$	p = 1.26 σ = 11.5	1690 to 1800	150 to 250 (200)	3.28 ±0.36	Nπ	~17	652
						Nππ	~70	624
						[Nε	~20][e]	468
						[Nρ	45-70][e]	297
						[Δπ	~20][e]	471
						ΛK	1-4	386
						ΣK	~ 2	307
						Nη	< 5	503
N(1990) →→→	$1/2(7/2^+)F_{17}$	p = 1.62 σ = 8.35	1950 to 2050	100 to 400 (250)	3.96 ±0.50	Nπ	~5	772
						Nη	~3	655
						ΛK	seen	562
						ΣK	seen	506
N(2190)	$1/2(7/2^-)G_{17}$	p = 2.07 σ = 6.21	2120 to 2180	<400 (250)	4.80 ±0.55	Nπ	~15	888
						Nη	~ 2	790
						ΛK	< 1	712
N(2200)	$1/2(9/2^-)G_{19}$	p = 2.10 σ = 6.12	2130 to 2270	200 to 350 (250)	4.84 ±0.55	Nπ	~10	894
						Nη	~ 2	810
N(2220)	$1/2(9/2^+)H_{19}$	p = 2.14 σ = 5.97	2150 to 2300	~300 (300)	4.93 ±0.67	Nπ	~20	905
						Nη	~ 1	811
N(2600) →	$1/2(11/2^-)I_{1\,11}$	p = 3.26 σ = 3.67	2580 to 2700	>300 (400)	6.76 ±1.04	Nπ	~ 5	1014
N(3030) →→	1/2(?)	p = 4.41 σ = 2.62	~3030	~400 (400)	9.18 ±1.21	Nπ	(J +1/2)x <0.1[k]	1366

Baryon Table *(cont'd)*

Particle[a]	I (J^P)[a] —— estab.	π or K beam[b] p_{beam} (GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass M[c] (MeV)	Full Width Γ[c] (MeV)	M^2 $\pm\Gamma M$[b] (GeV^2)	Partial decay mode[f] Mode	Fraction[c] %	p or p_{max}[d] (MeV/c)
			S=0 I=3/2 DELTA RESONANCES (Δ)					
Δ(1232)	$3/2(3/2^+)P'_{33}$	p = 0.30 σ = 94.3	1230 to 1234	110 to 120 (115)	1.52 ±0.14	Nπ $N\pi^+\pi^-$	~99.4 ~ 0	227 80
		Δ(++) Pole position:[l] Δ(0) Pole position:[l]	$M - i\Gamma/2 = (1211.0 \pm 0.8) - i(49.9 \pm 0.6)$ $M - i\Gamma/2 = (1210.5 \pm 1.0) - i(52.9 \pm 1.0)$					
Δ(1650)	$3/2(1/2^-)S'_{31}$	p = 0.96 σ = 16.4	1600 to 1650	120 to 160 (140)	2.72 ±0.23	Nπ Nππ [Nρ [Δπ	~32 ~65 <50][e] ~40][e]	547 511 *d* 344
Δ(1670)	$3/2(3/2^-)D_{33}$	p = 1.00 σ = 15.6	1630 to 1740	190 to 300 (200)	2.79 ±0.33	Nπ Nππ [Nρ [Δπ	~15 ~85 ~40][e] <50][e]	560 525 *d* 361
Δ(1690)	$3/2(3/2^+)P''_{33}$	p = 1.03 σ = 14.9	1500 to 1900[m]	150 to 350 (250)	2.86 ±0.42	Nπ Nππ [Nρ [Δπ	~20 ~80 <10][e] 30-45][e]	573 540 *d* 377
Δ(1890)	$3/2(5/2^+)F_{35}$	p = 1.42 σ = 9.88	1890 to 1930	250 to 400 (250)	3.57 ±0.47	Nπ Nππ [Nρ [Δπ ΣK	~15 ~80 ~60][e] 10-30][e] < 3	704 677 403 531 400
Δ(1910)	$3/2(1/2^+)P''_{31}$	p = 1.46 σ = 9.54	1850 to 1950	200 to 330 (220)	3.65 ±0.42	Nπ Nππ [Nρ [Δπ ΣK	20-25 >40 <40][e] small][e] 2-20	716 691 429 545 420
Δ(1950)	$3/2(7/2^+)F_{37}$	p = 1.54 σ = 8.90	1910 to 1950	200 to 340 (240)	3.80 ±0.47	Nπ Nππ [Nρ [Δπ ΣK	~40 >30 ~20][e] ~30][e] < 1	741 716 471 574 460
Δ(1960)	$3/2(5/2^-)D_{35}$	p = 1.56 σ = 8.75	1890 to 1940	150 to 300 (200)	3.84 ±0.39	Nπ ΣK	4-12 <10	748 469
Δ(2160)[n]	$3/2(\ ?^-)$	p = 2.00 σ = 6.46	2150 to 2280	200 to 440 (300)	4.67 ±0.65	Nπ	(J +1/2)x = 0.2 - 1.2 [k]	870
Δ(2420)	$3/2(11/2^+)H_{3\,11}$	p = 2.64 σ = 4.68	2380 to 2450	300 to 500 (300)	5.86 ±0.73	Nπ	~10	1023
Δ(2850)	$3/2(\ ?^+)$	p = 3.85 σ = 3.05	2800 to 2900	~400 (400)	8.12 ±1.14	Nπ	(J +1/2)x ~0.25 [k]	1266
Δ(3230)	3/2(?)	p = 5.08 σ = 2.25	3200 to 3350	~440 (440)	10.43 ±1.42	Nπ	(J +1/2)x ~0.05 [k]	1475
Z*		Evidence for states with strangeness +1 is inconclusive. See the Baryon Data Card Listings for data and discussion.						

Baryon Table *(cont'd)*

Particle[a]	I (J^P)[a] —— estab.	π or K beam[b] p_{beam} (GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass M[c] (MeV)	Full Width Γ[c] (MeV)	M^2 $\pm\Gamma M$[b] (GeV^2)	Partial decay mode[f] Mode	Fraction[c] %	p or p_{max}[d] (MeV/c)
			S=−1 I=0 LAMBDA RESONANCES (Λ)					
Λ	$0(1/2^+)$		1115.6		1.245	See Stable Particle Table		
Λ(1405)	$0(1/2^-)S'_{01}$	Below K^-p threshold	1405 ±5[o]	40 ± 10[o] (40)	1.97 ±0.06	Σπ	100	142
Λ(1520)	$0(3/2^-)D'_{03}$	p = 0.389 σ = 84.5	1519.5 ±1.5[o]	15.5 ± 1.5[o] (16)	2.31 ±0.02	$N\bar{K}$ Σπ Λππ Σππ	46 ± 1 42 ± 1 10 ± 1 0.9 ± 0.1	234 258 250 140
Λ(1670)	$0(1/2^-)S''_{01}$	p = 0.74 σ = 28.5	1660 to 1680	20 to 60 (40)	2.79 ±0.07	$N\bar{K}$ Λη Σπ	15-25 15-35 20-60	410 64 393
Λ(1690)	$0(3/2^-)D''_{03}$	p = 0.78 σ = 26.1	1690 ±10[o]	50 to 70 (60)	2.86 ±0.10	$N\bar{K}$ Σπ Λππ Σππ	20-30 20-40 ~25 ~20	429 409 415 352
Λ(1800)	$0(1/2^-)S'''_{01}$	p = 1.16 σ = 14.2	1700 to 1850	200 to 400 (300)	3.50 ±0.56	$N\bar{K}$ Σπ Σ(1385)π $N\bar{K}$*(892)	25-40 seen seen seen	525 488 346 *d*
Λ(1815)	$0(5/2^+)F'_{05}$	p = 1.05 σ = 16.7	1820 ±5[o]	70 to 90 (80)	3.29 ±0.15	$N\bar{K}$ Σπ Σ(1385)π	55-65 5-15 5-10	542 508 362
Λ(1830)	$0(5/2^-)D_{05}$	p = 1.09 σ = 15.8	1810 to 1830	60 to 110 (95)	3.35 ±0.17	$N\bar{K}$ Σπ Σ(1385)π	<10 35-75 >15	554 519 375
Λ(1860)	$0(3/2^+)P'_{03}$	p = 1.14 σ = 14.7	1850 to 1920	60 to 200 (100)	3.46 ±0.19	$N\bar{K}$ Σπ Σ(1385)π $N\bar{K}$*(892)	15-40 3-10 seen seen	576 534 396 162
Λ(2100)	$0(7/2^-)G_{07}$	p = 1.68 σ = 8.68	2080 to 2120	100 to 300 (250)	4.41 ±0.53	$N\bar{K}$ Σπ Λη ΞK Λω $N\bar{K}$*(892)	~30 ~ 5 < 3 < 3 < 8 10-20	748 699 617 483 443 514
Λ(2110)	$0(5/2^+)F''_{05}$	p = 1.70 σ = 8.48	2080 to 2140	150 to 250 (200)	4.45 ±0.42	$N\bar{K}$ Σπ $N\bar{K}$*(892) Λω Σ(1385)π	5-25 <40 20-60 seen seen	756 709 524 454 589
Λ(2350)	$0(9/2^+)$	p = 2.29 σ = 5.85	2340 to 2420	100 to 250 (120)	5.52 ±0.28	$N\bar{K}$ Σπ	~12 ~10	913 865
Λ(2585)	0(?)	p = 2.91 σ = 4.37	~2585	~300 (300)	6.68 ±0.78	$N\bar{K}$	(J+1/2)x ~1.0[k]	1058
			S=−1 I=1 SIGMA RESONANCES (Σ)					
Σ	$1(1/2^+)$		(+)1189.4 (0)1192.5 (−)1197.3		1.415 1.422 1.434	See Stable Particle Table		
Σ(1385)	$1(3/2^+)P'_{13}$	Below K^-p threshold	(+)1382.3±0.4 S = 1.6[p] (−)1387.5±0.6 S = 1.0[p] (0)1382.0±2.5 S = 1.6[p]	(+)35±2 S = 2.2[p] (−)40±2 S = 1.9[p] (35)	1.92 ±0.05	Λπ Σπ	88 ± 2 12 ± 2	208 117

Baryon Table *(cont'd)*

Particle[a]	I (J^P)[a] — estab.	π or K beam[b] p_{beam} (GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass M[c] (MeV)	Full Width Γ[c] (MeV)	M^2 ±ΓM[b] (GeV^2)	Partial decay mode[f] Mode	Fraction[c] %	p or p_{max}[d] (MeV/c)
Σ(1660)[q]	1(1/2$^+$)P'_{11}	p = 0.72 σ = 30.1	1580 to 1690	30 to 200 (100)	2.76 ±0.17	N$\bar{K}$ Σπ Λπ	<30 seen seen	402 383 440
Σ(1670)	1(3/2$^-$)D''_{13}	p = 0.74 σ = 28.5	1675 ±10[o]	40 to 60 (50)	2.79 ±0.08	N$\bar{K}$ Σπ Λπ	5-15 20-60 < 20	410 387 447
Σ(1750)	1(1/2$^-$)S''_{11}	p = 0.91 σ = 20.7	1730 to 1820	50 to 160 (75)	3.06 ±0.13	N$\bar{K}$ Λπ Σπ Ση	10-40 5-20 < 8 15-55	483 507 450 54
Σ(1765)	1(5/2$^-$)D_{15}	p = 0.94 σ = 19.6	1774 ±7[o]	105 to 135 (120)	3.12 ±0.21	N$\bar{K}$ Λπ Λ(1520)π Σ(1385)π Σπ	~41 ~14 ~19 ~ 9 ~ 1	496 518 187 315 461
Σ(1915)	1(5/2$^+$)F'_{15}	p = 1.25 σ = 13.0	1905 to 1930	70 to 160 (100)	3.67 ±0.19	N$\bar{K}$ Λπ Σπ Σ(1385)π	5-15 10-20 seen < 5	612 619 568 437
Σ(1940)[q]	1(3/2$^-$)D'''_{13}	p = 1.32 σ = 12.0	1900 to 1950	150 to 300 (220)	3.76 ±0.43	N$\bar{K}$ Λπ Σπ Λ(1520)π Δ(1232)$\bar{K}$ N$\bar{K}$*(892) Σ(1385)π	<20 seen seen seen seen seen seen	678 680 589 370 410 320 461
Σ(2030)	1(7/2$^+$)F_{17}	p = 1.52 σ = 9.93	2020 to 2040	120 to 200 (180)	4.12 ±0.37	N$\bar{K}$ Λπ Σπ ΞK Λ(1520)π Σ(1385)π Δ(1232)$\bar{K}$ N$\bar{K}$*(892)	~20 ~20 5-10 < 2 10-20 5-15 10-20 < 5	700 700 652 412 429 530 498 438
Σ(2250)[q]	1(?)[r]	p = 2.04 σ = 6.76	2200 to 2300	50 to 150 (100)	5.06 ±0.22	N$\bar{K}$ Λπ Σπ	< 10 seen seen	849 841 801
Σ(2455)	1(?)	p = 2.57 σ = 5.09	~2455	~120 (120)	6.03 ±0.29	N$\bar{K}$	(J+1/2)x ~0.2[k]	979
Σ(2620)	1(?)	p = 2.95 σ = 4.30	~2600	~200 (200)	6.86 ±0.52	N$\bar{K}$	(J+1/2)x ~0.3[k]	1064
			S=-2 I=1/2 CASCADE RESONANCES (Ξ)					
Ξ	1/2(1/2$^+$)		(0)1314.9 (-)1321.3		1.729 1.746	See Stable Particle Table		
Ξ(1530)	1/2(3/2$^+$)P_{13}		(0)1531.8±0.3 S = 1.3[p] (-)1535.0±0.6	(0)9.1±0.5 (-)10.1±1.9 (10)	2.34 ±0.02	Ξπ	100	144
Ξ(1820)	1/2(3/2)		1823 ±6[o]	20^{+15}_{-10}[o] (20)	3.31 ±0.04	Λ$\bar{K}$ Ξ(1530)π Σ$\bar{K}$ Ξπ	~45 ~45 ~10 small	396 234 306 413
Ξ(2030)	1/2(?)		2024 ±6[o]	16^{+15}_{-5}[o] (16)	4.12 ±0.03	Σ$\bar{K}$ Λ$\bar{K}$ Ξπ Ξ(1530)π	~80 ~20 small small	524 587 573 418
Ω^-	0(3/2$^+$)		1672.2±0.3		2.796	See Stable Particle Table		
Λ_c^+	0(1/2$^+$)		2273±6		5.17	See Stable Particle Table		

Baryon Table *(cont'd)*

For convenience all Baryon States for which information exists in the Baryon Data Card Listings are listed at the beginning of the Baryon Table. States with only a one or two star (*) rating in that list have been omitted from the main Baryon Table; each omitted state is indicated by an arrow in the left-hand margin of the Table. In the Listings there is an arrow under the name of each state omitted from the Table.

a. The names of the Baryon States in Col. 1 [such as N(1470)] contain a nominal mass which is primarily for purposes of identification. See Col. 4 for actual mass values. The convention for using primes in the spectroscopic notation for the quantum numbers in Col. 2 (such as P'_{11}) is as follows: no prime is attached when the Data Card Listings include only one resonance in the given partial wave; when there is more than one resonance, the first has been designated with a prime, the second with a double prime, etc. The name and the quantum numbers for each state are also given in large print at the beginning of the Data Card Listings for that state. See footnote a. of the Stable Particle Table for the strangeness quantum numbers of the baryons; in addition to the names listed there, we also use N and Δ for S=0 baryons, and Z* for S = +1 baryons.

b. The numbers in Col. 3 and Col. 6 are calculated using the nominal mass (see *a.* above) for M and the nominal width (see *c.* below) for Γ.

c. For masses, widths, and branching fractions of most baryons we report here a range instead of an average. Averages are appropriate if each result is based on independent measurements, but inappropriate where the spread in parameters arises because different models or procedures have been applied to a common set of data. The ranges given in the Table are generally chosen to be *conservatively large*. See the Data Card Listings for the individual values obtained in specific analyses. A single value with an approximation sign (~) indicates that there is not enough data to give a meaningful interval. A nominal width is included in parentheses in Col. 5; this nominal width is used to calculate the value of ΓM given in Col. 6.

d. For two-body decay modes we give the momentum, p, of the decay products in the decaying baryon rest frame. For decay modes into ⩾3 particles we give the maximum momentum, p_{max}, that any of the particles in the final state can have in this frame. The momenta are calculated using the nominal mass (see *a.* above) of the decaying baryon, and of any isobars in the final state. Some decays which would be energetically forbidden for the nominal masses actually occur because of the finite widths of the decaying baryon and/or isobars in the final state. In these cases, the decay momentum is omitted from Col. 9 and replaced with a reference to this footnote.

e. Square brackets around an isobar decay mode indicate that it is a sub-reaction of the previous unbracketed decay mode.

f. Many of the branching fractions in the Table are extracted from significantly more accurate results on $\sqrt{xx'}$ type couplings obtained in partial-wave analyses. The original $\sqrt{xx'}$ values are given in the Baryon Data Card Listings. For information on radiative decays of N's and Δ's, see the mini-review preceding the Baryon Data Card Listings.

g. The range given here does not include the widths of several hundred MeV reported by LONGACRE 75 and LONGACRE 77.

h. The range given here does not include the width of 550 MeV reported by SAXON 80.

i. The range given here does not include the branching ratio of approximately 80% reported by FELTESSE 75.

k. This state has been seen only in an energy-dependent fit to total, channel, or fixed angle cross-section data. J is not known; x is Γ_{el}/Γ.

l. See note on determination of resonance parameters in the Baryon Data Card Listings. Values of mass and width are dependent upon resonance shape used to fit the data. The pole position is much less dependent upon the parametrization used. The pole positions given here are taken from results (in the Data Card Listings) of fits to phase shifts without Coulomb corrections.

m. There may be more than one P_{33} resonance in or near this mass range.

n. There is probably more than one Δ resonance near 2160 MeV. The parameter ranges in the Table include the various possibilities. See the Baryon Data Card Listings.

o. The error given here is only an educated guess; it is larger than the error of the average of the published values (see the Baryon Data Card Listings for the latter).

p. Quoted error includes a S (scale) factor. See second footnote to Stable Particle Table.

q. Because the elastic branching fraction of this resonance is poorly determined, it is not possible to extract inelastic branching fractions from partial-wave couplings. See the Baryon Data Card Listings for the partial-wave couplings.

r. Recent partial-wave analyses of the College de France-Saclay group find evidence for a $5/2^-$ and a $9/2^-$ Σ resonance at this mass. See the Baryon Data Card Listings.

PHYSICAL AND NUMERICAL CONSTANTS*

PHYSICAL CONSTANTS

Quantity	Value	Uncert. (ppm)
N_A	$= 6.022\,045(31)\times10^{23}$ mole^{-1}	5.1
V_m	$= 22413.83(70)$ cm^3 mole^{-1} = molar volume of ideal gas at STP	31
c	$= 2.997\,924\,58(1.2)\times10^{10}$ cm sec^{-1}	0.004
e	$= 4.803\,242(14)\times10^{-10}$ esu $= 1.602\,189\,2(46)\times10^{-19}$ coulomb	2.9; 2.9
1 MeV	$= 1.602\,189\,2(46)\times10^{-6}$ erg	2.9
$\hbar=h/2\pi$	$= 6.582\,173(17)\times10^{-22}$ MeV sec $= 1.054\,588\,7(57)\times10^{-27}$ erg sec	2.6; 5.4
$\hbar c$	$= 1.973\,285\,8(51)\times10^{-11}$ MeV cm $= 197.32858(51)$ MeV fermi	2.6; 2.6
$(\hbar c)^2$	$= 0.389\,385\,7(20)$ GeV^2 mb	5.2
α	$= e^2/\hbar c = 1/137.03604(11)$	0.82
$k_{\text{Boltzmann}}$	$= 1.380\,662(44)\times10^{-16}$ erg °K^{-1}	32
	$= 8.61735(28)\times10^{-11}$ MeV °K^{-1} = 1 eV/11604.50(36) °K	32; 31
$\sigma_{\text{Stef. Boltz.}}$	$= 5.67032(71)\times10^{-5}$ erg sec^{-1} cm^{-2} °K^{-4}	125
	$= 3.53911(44)\times10^{7}$ eV sec^{-1} cm^{-2} °K^{-4}	125
m_e	$= 0.511\,003\,4(14)$ MeV $= 9.109\,534(47)\times10^{-28}$ g	2.8; 5.1
m_p	$= 938.2796(27)$ MeV $= 1836.15152(70)\,m_e = 6.722\,795(61)\,m_{\pi\pm}$	2.8; 0.38; 9.0
	$= 1.007\,276\,470(11)$ amu	0.011
1 amu	$= 1/12\,m_{C12} = 931.5016(26)$ MeV	2.8
m_d	$= 1875.6280(53)$ MeV	2.8
r_e	$= e^2/m_ec^2 = 2.817\,938\,0(70)$ fermi (1 fermi $= 10^{-13}$ cm)	2.5
$\lambda\!\!\!^{-}_e$	$= \hbar/m_ec = r_e\alpha^{-1} = 3.861\,590\,5(64)\times10^{-11}$ cm	1.6
$a_{\infty\text{Bohr}}$	$= \hbar^2/m_ee^2 = r_e\alpha^{-2} = 0.529\,177\,06(44)$ Å (1 Å $= 10^{-8}$ cm)	0.82
σ_{Thomson}	$= (8/3)\pi r_e^2 = 0.665\,244\,8(33)$barn (1 barn $= 10^{-24}$ cm^2)	4.9
μ_{Bohr}	$= e\hbar/2m_ec = 0.578\,837\,85(95)\times10^{-14}$ MeV gauss^{-1}	1.6
μ_N	$= e\hbar/2m_pc = 3.152\,451\,5(53)\times10^{-18}$ MeV gauss^{-1}	1.7
μ_p/μ_{Bohr}	$= 0.001\,521\,032\,209(16)$	0.011
$1/2\omega^e_{\text{cyclotron}}$	$= e/2m_ec = 8.794\,024(25)\times10^{6}$ rad sec^{-1} gauss^{-1}	2.8
$1/2\omega^p_{\text{cyclotron}}$	$= e/2m_pc = 4.789\,378(14)\times10^{3}$ rad sec^{-1} gauss^{-1}	2.8

Hydrogen-like atom (nonrelativistic, μ = reduced mass):

$$\frac{v}{c}\Big)_{rms} = \frac{z\alpha}{n};\quad E_n = \frac{\mu}{2}v^2 = \frac{\mu}{2}\left(\frac{cz\alpha}{n}\right)^2;\quad a_n = \frac{n^2\hbar}{\mu zc\alpha}$$

Quantity	Value	Uncert. (ppm)
$R_\infty = m_ee^4/2\hbar^2 = m_ec^2\alpha^2/2$	$= 13.605\,804(36)$ eV (Rydberg)	2.6
	$= m_ec\alpha^2/2h = 109\,737.3177(83)$ cm^{-1}	0.075
$pc = 0.3\,H\rho$ (MeV, kilogauss, cm)		
1 year (sidereal)	= 365.256 days $= 3.1558\times10^7$ sec ($\approx\pi\times10^7$ sec)	
density of dry air	= 1.204 mg cm^{-3} (at 20°C, 760 mm)	
acceleration by gravity	= 980.62 cm sec^{-2} (sea level, 45°)	
gravitational constant	$= 6.6720(41)\times10^{-8}$ cm^3 g^{-1} sec^{-2}	615
1 calorie (thermochemical)	= 4.184 joules	
1 atmosphere	= 1.01325 bar (1 bar $= 10^6$ dynes cm^{-2})	
1 eV per particle	= 11604.50(36) °K (from E = kT)	31

NUMERICAL CONSTANTS

π	= 3.141 592 7	1 rad	= 57.295 779 5 deg	$\sqrt{\pi}$	= 1.772 453 85
e	= 2.718 281 8	$1/e$	= 0.367 879 4	$\sqrt{2}$	= 1.414 213 6
ln2	= 0.693 147 2	ln10	= 2.302 585 1	$\sqrt{3}$	= 1.732 050 8
$\log_{10}2$	= 0.301 030 0	$\log_{10}e$	= 0.434 294 5	$\sqrt{10}$	= 3.162 277 7

*Revised April 1980 by Barry N. Taylor. Originally prepared by Stanley J. Brodsky, based mainly on the "1973 Least-Squares Adjustment of the Fundamental Constants," by E. R. Cohen and B. N. Taylor, J. Phys. Chem. Ref. Data 2, 663 (1973). The figures in parentheses correspond to the one-standard-deviation uncertainty in the last digits of the main number. The equivalent uncertainty in parts per million (ppm) is given in the last column. Note that the uncertainties of the output values of a least-squares adjustment are in general correlated, and the general law of error propagation must be used in calculating additional quantities.

The set of constants resulting from the 1973 adjustment of Cohen and Taylor has been recommended for international use by CODATA (Committee on Data for Science and Technology), and is the most up-to-date, generally accepted set currently available. However, since the publication of the 1973 adjustment, a number of new experiments have been completed, yielding improved values for some of the constants: $N_A = 6.022\,097\,8(63)\times10^{23}$ mole^{-1} (1.04 ppm); $\alpha^{-1} = 137.035\,963(15)$ (0.11 ppm) [obtained using the Josephson effect]; and $R_\infty = 109\,737.314\,76(32)$ cm^{-1} (0.003 ppm). But it must be realized that, since the output values of a least-squares adjustment are related in a complex way and a change in the measured value of one constant usually leads to corresponding changes in the adjusted values of others, one must be cautious in carrying out calculations using both the output values from the 1973 adjustment and the results of more recent experiments. A new adjustment is planned for completion by early 1982.

CLEBSCH-GORDAN COEFFICIENTS, SPHERICAL HARMONICS, AND d FUNCTIONS

Note: A $\sqrt{\ }$ is to be understood over every coefficient; e.g., for -8/15 read $-\sqrt{8/15}$.

Notation:

m_1 m_2	J M	J M	...
m_1 m_2	Coefficients		
. .			

1/2 × 1/2

m_1 m_2	1 +1
+1/2 +1/2	1

m_1 m_2	1 0	0 0
+1/2 -1/2	1/2	1/2
-1/2 +1/2	1/2	-1/2

m_1 m_2	1 -1
-1/2 -1/2	1

1 × 1/2

m_1 m_2	3/2 +3/2
+1 +1/2	1

m_1 m_2	3/2 +1/2	1/2 +1/2
+1 -1/2	1/3	2/3
0 +1/2	2/3	-1/3

m_1 m_2	3/2 -1/2	1/2 -1/2
0 -1/2	2/3	1/3
-1 +1/2	1/3	-2/3

m_1 m_2	3/2 -3/2
-1 -1/2	1

2 × 1

m_1 m_2	3 +3
+2 +1	1

m_1 m_2	3 +2	2 +2
+2 0	1/3	2/3
+1 +1	2/3	-1/3

m_1 m_2	3 +1	2 +1	1 +1
+2 -1	1/15	1/3	3/5
+1 0	8/15	1/6	-3/10
0 +1	6/15	-1/2	1/10

m_1 m_2	3 0	2 0	1 0
+1 -1	1/5	1/2	3/10
0 0	3/5	0	-2/5
-1 +1	1/5	-1/2	3/10

m_1 m_2	3 -1	2 -1	1 -1
0 -1	6/15	1/2	1/10
-1 0	8/15	-1/6	-3/10
-2 +1	1/15	-1/3	3/5

m_1 m_2	3 -2	2 -2
-1 -1	2/3	1/3
-2 0	1/3	-2/3

m_1 m_2	3 -3
-2 -1	1

1 × 1

m_1 m_2	2 +2
+1 +1	1

m_1 m_2	2 +1	1 +1
+1 0	1/2	1/2
0 +1	1/2	-1/2

m_1 m_2	2 0	1 0	0 0
+1 -1	1/6	1/2	1/3
0 0	2/3	0	-1/3
-1 +1	1/6	-1/2	1/3

m_1 m_2	2 -1	1 -1
0 -1	1/2	1/2
-1 0	1/2	-1/2

m_1 m_2	2 -2
-1 -1	1

$$Y_1^0 = \sqrt{\frac{3}{4\pi}}\cos\theta$$

$$Y_1^1 = -\sqrt{\frac{3}{8\pi}}\sin\theta\, e^{i\phi}$$

$$Y_2^0 = \sqrt{\frac{5}{4\pi}}\left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right)$$

$$Y_2^1 = -\sqrt{\frac{15}{8\pi}}\sin\theta\cos\theta\, e^{i\phi}$$

$$Y_2^2 = \frac{1}{4}\sqrt{\frac{15}{2\pi}}\sin^2\theta\, e^{2i\phi}$$

$$Y_\ell^{-m} = (-1)^m Y_\ell^{m*}$$

$$d^\ell_{m,0} = \sqrt{\frac{4\pi}{2\ell+1}}\, Y_\ell^m\, e^{-im\phi}$$

2 × 1/2

m_1 m_2	5/2 +5/2
+2 1/2	1

m_1 m_2	5/2 +3/2	3/2 +3/2
+2 -1/2	1/5	4/5
+1 +1/2	4/5	-1/5

m_1 m_2	5/2 +1/2	3/2 +1/2
+1 -1/2	2/5	3/5
0 +1/2	3/5	-2/5

m_1 m_2	5/2 -1/2	3/2 -1/2
0 -1/2	3/5	2/5
-1 +1/2	2/5	-3/5

m_1 m_2	5/2 -3/2	3/2 -3/2
-1 -1/2	4/5	1/5
-2 +1/2	1/5	-4/5

m_1 m_2	5/2 -5/2
-2 -1/2	1

3/2 × 1/2

m_1 m_2	2 +2
+3/2 +1/2	1

m_1 m_2	2 +1	1 +1
+3/2 -1/2	1/4	3/4
+1/2 +1/2	3/4	-1/4

m_1 m_2	2 0	1 0
+1/2 -1/2	1/2	1/2
-1/2 +1/2	1/2	-1/2

m_1 m_2	2 -1	1 -1
-1/2 -1/2	3/4	1/4
-3/2 +1/2	1/4	-3/4

m_1 m_2	2 -2
-3/2 -1/2	1

3/2 × 1

m_1 m_2	5/2 +5/2
+3/2 +1	1

m_1 m_2	5/2 +3/2	3/2 +3/2
+3/2 0	2/5	3/5
+1/2 +1	3/5	-2/5

m_1 m_2	5/2 +1/2	3/2 +1/2	1/2 +1/2
+3/2 -1	1/10	2/5	1/2
+1/2 0	3/5	1/15	-1/3
-1/2 +1	3/10	-8/15	1/6

m_1 m_2	5/2 -1/2	3/2 -1/2	1/2 -1/2
+1/2 -1	3/10	8/15	1/6
-1/2 0	3/5	-1/15	-1/3
-3/2 +1	1/10	-2/5	1/2

m_1 m_2	5/2 -3/2	3/2 -3/2
-1/2 -1	3/5	2/5
-3/2 0	2/5	-3/5

m_1 m_2	5/2 -5/2
-3/2 -1	1

$$\langle j_1 j_2 m_1 m_2 | j_1 j_2 J M\rangle = (-1)^{J-j_1-j_2}\langle j_2 j_1 m_2 m_1 | j_2 j_1 J M\rangle$$

$$d^j_{m',m} = (-1)^{m-m'} d^j_{m,m'} = d^j_{-m,-m'}$$

3/2 × 3/2

m_1 m_2	3 +3
+3/2 +3/2	1

m_1 m_2	3 +2	2 +2
+3/2 +1/2	1/2	1/2
+1/2 +3/2	1/2	-1/2

m_1 m_2	3 +1	2 +1	1 +1
+3/2 -1/2	1/5	1/2	3/10
+1/2 +1/2	3/5	0	-2/5
-1/2 +3/2	1/5	-1/2	3/10

m_1 m_2	3 0	2 0	1 0	0 0
+3/2 -3/2	1/20	1/4	9/20	1/4
+1/2 -1/2	9/20	1/4	-1/20	-1/4
-1/2 +1/2	9/20	-1/4	-1/20	1/4
-3/2 +3/2	1/20	-1/4	9/20	-1/4

m_1 m_2	3 -1	2 -1	1 -1
+1/2 -3/2	1/5	1/2	3/10
-1/2 -1/2	3/5	0	-2/5
-3/2 +1/2	1/5	-1/2	3/10

m_1 m_2	3 -2	2 -2
-1/2 -3/2	1/2	1/2
-3/2 -1/2	1/2	-1/2

m_1 m_2	3 -3
-3/2 -3/2	1

2 × 3/2

m_1 m_2	7/2 +7/2
+2 +3/2	1

m_1 m_2	7/2 +5/2	5/2 +5/2
+2 +1/2	3/7	4/7
+1 +3/2	4/7	-3/7

m_1 m_2	7/2 +3/2	5/2 +3/2	3/2 +3/2
+2 -1/2	1/7	16/35	2/5
+1 +1/2	4/7	1/35	-2/5
0 +3/2	2/7	-18/35	1/5

m_1 m_2	7/2 +1/2	5/2 +1/2	3/2 +1/2	1/2 +1/2
+2 -3/2	1/35	6/35	2/5	2/5
+1 -1/2	12/35	5/14	0	-3/10
0 +1/2	18/35	-3/35	-1/5	1/5
-1 +3/2	4/35	-27/70	2/5	-1/10

m_1 m_2	7/2 -1/2	5/2 -1/2	3/2 -1/2	1/2 -1/2
+1 -3/2	4/35	27/70	2/5	1/10
0 -1/2	18/35	3/35	-1/5	-1/5
-1 +1/2	12/35	-5/14	0	3/10
-2 +3/2	1/35	-6/35	2/5	-2/5

m_1 m_2	7/2 -3/2	5/2 -3/2	3/2 -3/2
0 -3/2	2/7	18/35	1/5
-1 -1/2	4/7	-1/35	-2/5
-2 +1/2	1/7	-16/35	2/5

m_1 m_2	7/2 -5/2	5/2 -5/2
-1 -3/2	4/7	3/7
-2 -1/2	3/7	-4/7

m_1 m_2	7/2 -7/2
-2 -3/2	1

2 × 2

m_1 m_2	4 +4
+2 +2	1

m_1 m_2	4 +3	3 +3
+2 +1	1/2	1/2
+1 +2	1/2	-1/2

m_1 m_2	4 +2	3 +2	2 +2
+2 0	3/14	1/2	2/7
+1 1	4/7	0	-3/7
0 2	3/14	-1/2	2/7

m_1 m_2	4 +1	3 +1	2 +1	1 +1
+2 -1	1/14	3/10	3/7	1/5
+1 0	3/7	1/5	-1/14	-3/10
0 1	3/7	-1/5	-1/14	3/10
-1 2	1/14	-3/10	3/7	-1/5

m_1 m_2	4 0	3 0	2 0	1 0	0 0
+2 -2	1/70	1/10	2/7	2/5	1/5
+1 -1	8/35	2/5	1/14	-1/10	-1/5
0 0	18/35	0	-2/7	0	1/5
-1 1	8/35	-2/5	1/14	1/10	-1/5
-2 2	1/70	-1/10	2/7	-2/5	1/5

m_1 m_2	4 -1	3 -1	2 -1	1 -1
+1 -2	1/14	3/10	3/7	1/5
0 -1	3/7	1/5	-1/14	-3/10
-1 0	3/7	-1/5	-1/14	3/10
-2 1	1/14	-3/10	3/7	-1/5

m_1 m_2	4 -2	3 -2	2 -2
0 -2	3/14	1/2	2/7
-1 -1	4/7	0	-3/7
-2 0	3/14	-1/2	2/7

m_1 m_2	4 -3	3 -3
-1 -2	1/2	1/2
-2 -1	1/2	-1/2

m_1 m_2	4 -4
-2 -2	1

$$d^{1/2}_{1/2,1/2} = \cos\frac{\theta}{2} \qquad d^{1/2}_{1/2,-1/2} = -\sin\frac{\theta}{2}$$

$$d^1_{1,1} = \frac{1+\cos\theta}{2} \qquad d^1_{1,0} = -\frac{\sin\theta}{\sqrt{2}}$$

$$d^1_{1,-1} = \frac{1-\cos\theta}{2} \qquad d^1_{0,0} = \cos\theta$$

$$d^{3/2}_{3/2,3/2} = \frac{1+\cos\theta}{2}\cos\frac{\theta}{2}$$

$$d^{3/2}_{3/2,1/2} = -\sqrt{3}\,\frac{1+\cos\theta}{2}\sin\frac{\theta}{2}$$

$$d^{3/2}_{3/2,-1/2} = \sqrt{3}\,\frac{1-\cos\theta}{2}\cos\frac{\theta}{2}$$

$$d^{3/2}_{3/2,-3/2} = -\frac{1-\cos\theta}{2}\sin\frac{\theta}{2}$$

$$d^{3/2}_{1/2,1/2} = \frac{3\cos\theta-1}{2}\cos\frac{\theta}{2}$$

$$d^{3/2}_{1/2,-1/2} = -\frac{3\cos\theta+1}{2}\sin\frac{\theta}{2}$$

$$d^2_{2,2} = \left(\frac{1+\cos\theta}{2}\right)^2$$

$$d^2_{2,1} = -\frac{1+\cos\theta}{2}\sin\theta$$

$$d^2_{2,0} = \frac{\sqrt{6}}{4}\sin^2\theta$$

$$d^2_{2,-1} = -\frac{1-\cos\theta}{2}\sin\theta$$

$$d^2_{2,-2} = \left(\frac{1-\cos\theta}{2}\right)^2$$

$$d^2_{1,1} = \frac{1+\cos\theta}{2}(2\cos\theta-1)$$

$$d^2_{1,0} = -\sqrt{\frac{3}{2}}\sin\theta\cos\theta$$

$$d^2_{1,-1} = \frac{1-\cos\theta}{2}(2\cos\theta+1)$$

$$d^2_{0,0} = \left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right)$$

Sign convention is that of Wigner (Group Theory, Academic Press, New York, 1959), also used by Condon and Shortley (The Theory of Atomic Spectra, Cambridge Univ. Press, New York, 1953), Rose (Elementary Theory of Angular Momentum, Wiley, New York, 1957), and Cohen (Tables of the Clebsch-Gordan Coefficients, North American Rockwell Science Center, Thousand Oaks, Calif., 1974). The signs and numbers in the current tables have been calculated by computer programs written independently by Cohen and at LBL. (Table extended April 1974.)

SU(3) ISOSCALAR FACTORS

The most commonly used isoscalar factors, corresponding to the singlet, octet, and decuplet content of $8 \otimes 8$ and $10 \otimes 8$, are displayed at the right. The notation uses particles names to identify the coefficients, so that the pattern of relative couplings can be seen at a glance. We illustrate the use of the coefficients by example; see J. J. de Swart, Rev. Mod. Phys. 35, 916 (1963) for detailed explanation and phase conventions.

A $\sqrt{\ }$ is understood over every integer in the matrices; the exponent $\frac{1}{2}$ is a reminder of this. For example, in de Swart's notation the $\Xi \to \Omega K$ element of our $10 \to 10 \otimes 8$ matrix reads

$$\left(\begin{matrix} 10 & \\ 0 & -2 \end{matrix}\;\begin{matrix} & 8 \\ \frac{1}{2} & 1 \end{matrix}\;\middle|\;\begin{matrix} 10 & \\ \frac{1}{2} & -1 \end{matrix}\right) = \frac{-\sqrt{6}}{\sqrt{24}} .$$

Intra-multiplet relative decay strengths can be read directly from our matrices. Thus, the partial widths for $\Delta^* \to (N\pi)_{I=3/2}$ and $\Omega^* \to (\Xi\bar{K})_{I=0}$ are in the ratio

$$\frac{\Gamma(\Omega^* \to (\Xi\bar{K})_{I=0})}{\Gamma(\Delta^* \to (N\pi)_{I=3/2})} = \frac{12}{6} \times (\text{threshold factors}) .$$

Supplying isospin Clebsch-Gordan coefficients one obtains, e.g.,

$$\frac{\Gamma(\Omega^{*-} \to \Xi^0 K^-)}{\Gamma(\Delta^{*+} \to p\pi^0)} = \frac{1/2}{2/3} \times \frac{12}{6} \times \text{tf} = \frac{3}{2} \times \text{tf} .$$

Partial widths for $8 \to 8 \otimes 8$ involve a linear superposition of 8_1 (symmetric) and 8_2 (anti-symmetric) couplings. For example,

$$\Gamma(\Xi^* \to \Xi\pi) \sim \left(-\sqrt{\frac{9}{20}}\, g_1 + \sqrt{\frac{3}{12}}\, g_2\right)^2 .$$

The relation between g_1, g_2 (with de Swart's normalization) and the standard D,F couplings appearing in the interaction Lagrangian,

$$\mathcal{L} = -\sqrt{2}\, D\, \mathrm{Tr}([\bar{B},B]_+ M) + \sqrt{2}\, F\, \mathrm{Tr}([\bar{B},B]_- M) ,$$

is

$$D = \frac{\sqrt{30}}{40} g_1 , \qquad F = \frac{\sqrt{6}}{24} g_2 .$$

Thus, $\Gamma(\Xi^* \to \Xi\pi) \sim (1 - 2\alpha)^2$

where $\alpha \equiv D/(D+F)$.

$1 \to 8 \otimes 8$

$$(\Lambda)_1 \to (N\bar{K} \quad \Sigma\pi \quad \Lambda\eta \quad \Xi K)_{8 \otimes 8} = \frac{1}{\sqrt{8}} (2 \quad 3 \quad -1 \quad -2)^{\frac{1}{2}}$$

$8_1 \to 8 \otimes 8$

$$\begin{pmatrix} N \\ \Sigma \\ \Lambda \\ \Xi \end{pmatrix}_{8_1} \to \begin{pmatrix} N\pi & N\eta & \Sigma K & \Lambda K \\ N\bar{K} & \Sigma\pi & \Lambda\pi & \Sigma\eta & \Xi K \\ N\bar{K} & \Sigma\pi & \Lambda\eta & \Xi K \\ \Sigma\bar{K} & \Lambda\bar{K} & \Xi\pi & \Xi\eta \end{pmatrix}_{8 \otimes 8} = \frac{1}{\sqrt{20}} \begin{pmatrix} 9 & -1 & -9 & -1 \\ -6 & 0 & 4 & 4 & -6 \\ 2 & -12 & -4 & -2 \\ 9 & -1 & -9 & -1 \end{pmatrix}^{\frac{1}{2}}$$

$8_2 \to 8 \otimes 8$

$$\begin{pmatrix} N \\ \Sigma \\ \Lambda \\ \Xi \end{pmatrix}_{8_2} \to \begin{pmatrix} N\pi & N\eta & \Sigma K & \Lambda K \\ N\bar{K} & \Sigma\pi & \Lambda\pi & \Sigma\eta & \Xi K \\ N\bar{K} & \Sigma\pi & \Lambda\eta & \Xi K \\ \Sigma\bar{K} & \Lambda\bar{K} & \Xi\pi & \Xi\eta \end{pmatrix}_{8 \otimes 8} = \frac{1}{\sqrt{12}} \begin{pmatrix} 3 & 3 & 3 & -3 \\ 2 & 8 & 0 & 0 & -2 \\ 6 & 0 & 0 & 6 \\ 3 & 3 & 3 & -3 \end{pmatrix}^{\frac{1}{2}}$$

$10 \to 8 \otimes 8$

$$\begin{pmatrix} \Delta \\ \Sigma \\ \Xi \\ \Omega \end{pmatrix}_{10} \to \begin{pmatrix} N\pi & \Sigma K \\ N\bar{K} & \Sigma\pi & \Lambda\pi & \Sigma\eta & \Xi K \\ \Sigma\bar{K} & \Lambda\bar{K} & \Xi\pi & \Xi\eta \\ \Xi\bar{K} \end{pmatrix}_{8 \otimes 8} = \frac{1}{\sqrt{12}} \begin{pmatrix} -6 & 6 \\ -2 & 2 & -3 & 3 & 2 \\ 3 & -3 & 3 & 3 \\ 12 \end{pmatrix}^{\frac{1}{2}}$$

$8 \to 10 \otimes 8$

$$\begin{pmatrix} N \\ \Sigma \\ \Lambda \\ \Xi \end{pmatrix}_{8} \to \begin{pmatrix} \Delta\pi & \Sigma K \\ \Delta\bar{K} & \Sigma\pi & \Sigma\eta & \Xi K \\ \Sigma\pi & \Xi K \\ \Sigma\bar{K} & \Xi\pi & \Xi\eta & \Omega K \end{pmatrix}_{10 \otimes 8} = \frac{1}{\sqrt{15}} \begin{pmatrix} -12 & 3 \\ 8 & -2 & -3 & 2 \\ -9 & 6 \\ 3 & -3 & -3 & 6 \end{pmatrix}^{\frac{1}{2}}$$

$10 \to 10 \otimes 8$

$$\begin{pmatrix} \Delta \\ \Sigma \\ \Xi \\ \Omega \end{pmatrix}_{10} \to \begin{pmatrix} \Delta\pi & \Delta\eta & \Sigma K \\ \Delta\bar{K} & \Sigma\pi & \Sigma\eta & \Xi K \\ \Sigma\bar{K} & \Xi\pi & \Xi\eta & \Omega K \\ \Xi\bar{K} & \Omega\eta \end{pmatrix}_{10 \otimes 8} = \frac{1}{\sqrt{24}} \begin{pmatrix} 15 & 3 & -6 \\ 8 & 8 & 0 & -8 \\ 12 & 3 & -3 & -6 \\ 12 & -12 \end{pmatrix}^{\frac{1}{2}}$$

SU(n) Multiplicities

The table below gives the multiplicities of the multiplets that occur in qq, $q\bar{q}$, and qqq systems in various SU(n). Normal mesons are $q\bar{q}$ systems, and normal baryons are qqq systems. Also given are the multiplets that occur in meson-baryon scattering when the meson multiplet is the one to which the pion belongs and the baryon multiplet is the one to which the proton belongs. Complex-conjugate representations are indicated by a bar. The two 20-dimensional representations of SU(4) are indicated as 20 (which contains the SU(3) decuplet) and 20' (which contains the SU(3) octet). The C(N,M)'s are the binomial coefficients N!/[M!(N-M)!].

qq		
SU(2):	$2 \otimes 2$	$\to 3 \oplus 1$
SU(3):	$3 \otimes 3$	$\to 6 \oplus \bar{3}$
SU(4):	$4 \otimes 4$	$\to 10 \oplus 6$
SU(n):	$n \otimes n$	$\to n(n+1)/2 \oplus n(n-1)/2$

$q\bar{q}$ (Mesons)		
SU(2):	$2 \otimes \bar{2}$	$\to 3 \oplus 1$
SU(3):	$3 \otimes \bar{3}$	$\to 8 \oplus 1$
SU(4):	$4 \otimes \bar{4}$	$\to 15 \oplus 1$
SU(n):	$n \otimes \bar{n}$	$\to (n^2-1) \oplus 1$

qqq (Baryons)		
SU(2):	$2 \otimes 2 \otimes 2$	$\to 4 \oplus 2 \oplus 2$
SU(3):	$3 \otimes 3 \otimes 3$	$\to 10 \oplus 8 \oplus 8 \oplus 1$
SU(4):	$4 \otimes 4 \otimes 4$	$\to 20 \oplus 20' \oplus 20' \oplus \bar{4}$
SU(n):	$n \otimes n \otimes n$	$\to C(n+2,3) \oplus 2C(n+1,3) \oplus 2C(n+1,3) \oplus C(n,3)$

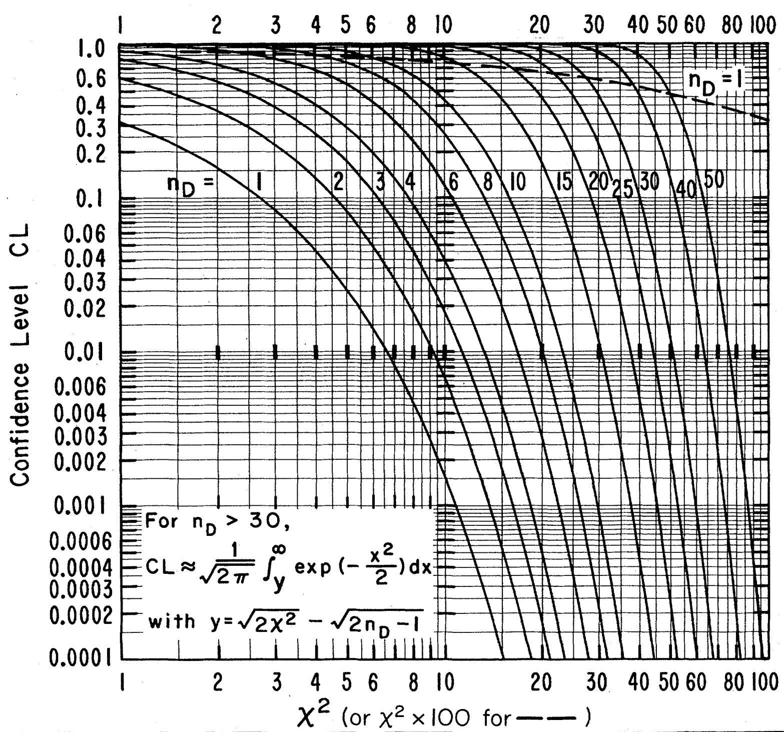
Meson-Baryon Scattering		
SU(2):	$3 \otimes 2$	$\to 4 \oplus 2$
SU(3):	$8 \otimes 8$	$\to 27 \oplus 10 \oplus \overline{10} \oplus 8 \oplus 8 \oplus 1$
SU(4):	$15 \otimes 20'$	$\to 140 \oplus 60 \oplus 36 \oplus 20 \oplus 20' \oplus 20' \oplus \bar{4}$

PROBABILITY AND STATISTICS

A. PROBABILITY DISTRIBUTIONS AND CONFIDENCE LEVELS

We give here properties of the three probability distributions most commonly used in high energy physics: Normal (or Gaussian), Chi-squared, and Poisson. We warn the reader that there is no universal convention for the term "confidence level" as used by physicists; thus, explicit definitions are given for each distribution, and we have attempted to choose definitions that correspond to common usage. It is explained below how confidence levels for all three distributions can be extracted from the following figure.

χ^2 Confidence Level vs. χ^2 for n_D Degrees of Freedom



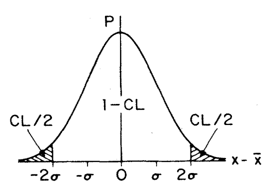
A.1. Normal Distribution

The normal distribution with mean $\bar{x}$ and standard deviation σ (variance σ^2) is:

$$P(x)dx = \frac{1}{\sqrt{2\pi}\sigma} e^{-(x-\bar{x})^2/2\sigma^2} dx. \tag{1}$$

The confidence level associated with an observed deviation from the mean, δ, is the probability that $|x-\bar{x}| > \delta$, i.e.,

$$CL = 2\int_{\bar{x}+\delta}^{\infty} dx\, P(x) \tag{2}$$



[The small figure in Eq. (2) is drawn with $\delta = 2\sigma$.] CL is given by the ordinate of the $n_D = 1$ curve in the figure at $\chi^2 = (\delta/\sigma)^2$. The confidence level for $\delta = 1\sigma$ is 31.7%; 2σ, 4.6%; 3σ, 0.3%. The central confidence interval, 1-CL, (which is also sometimes called confidence level) for $\delta = 1\sigma$ is 68.3%; 2σ, 95.4%; 3σ, 99.7%. The odds against exceeding δ, (1-CL)/CL, for $\delta = 1\sigma$ are 2.15:1; 2σ, 21:1; 3σ, 370:1; 4σ, 16,000:1; 5σ, 1,700,000:1. Relations between σ and other measures of the width: probable error (CL = 0.5 deviation) = 0.67σ; mean absolute deviation = 0.80σ; RMS deviation = σ; half width at half maximum = 1.18σ.

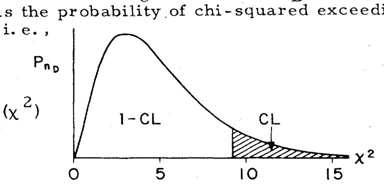
A.2. Chi-squared Distribution

The chi-squared distribution for n_D degrees of freedom is:

$$P_{n_D}(\chi^2)d\chi^2 = \frac{1}{2^h\Gamma(h)} (\chi^2)^{h-1} e^{-\chi^2/2} d\chi^2 \quad (\chi^2 \geq 0), \tag{3}$$

where h (for "half") = $n_D/2$. The mean and variance are n_D and $2n_D$, respectively. In evaluating Eq. (3) one may use Stirling's approximation: $\Gamma(h) = (h-1)! \approx 2.507\, e^{-h} h^{(h-1/2)} \times (1 + 0.0833/h)$ which is accurate to ± 0.1% for all $h \geq 1/2$. The confidence level associated with a given value of n_D and an observed value of χ^2 is the probability of chi-squared exceeding the observed value, i.e.,

$$CL = \int_{\chi^2}^{\infty} d\chi^2\, P_{n_D}(\chi^2) \tag{4}$$



[The small figure in Eq. (4) is drawn with $n_D = 5$ and CL = 10%.] CL is plotted as a function of χ^2 for several values of n_D in the above figure. For large n_D, χ^2 becomes normally distributed about n_D. Thus,

$$y_1 = (\chi^2 - n_D)/\sqrt{2n_D} \tag{5}$$

becomes normally distributed with unit standard deviation. A better approximation, due to Fisher,[1] is that χ, not χ^2, becomes normally distributed, specifically

$$y_2 = \sqrt{2\chi^2} - \sqrt{2n_D - 1} \tag{6}$$

approaches normality with unit standard deviation. For small CL's in particular, y_2 is much more accurate than y_1. Thus, for $n_D = 50$ and $\chi^2 = 80$, the true CL = 0.45%, but y_1 is 3.0 corresponding to a CL of 0.13%, while y_2 is 2.7 corresponding to a CL of 0.35%.

PROBABILITY AND STATISTICS (Cont'd)

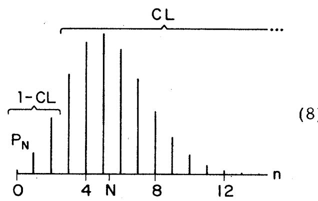
A.3. Poisson Distribution

The Poisson distribution with mean $\bar{n}$ is:

$$P_{\bar{n}}(n) = \frac{e^{-(\bar{n})}(\bar{n})^n}{n!} \quad (n = 0, 1, 2, \cdots) \, . \tag{7}$$

The variance is equal to the mean. Confidence levels for Poisson distributions are usually defined in terms of quantities called "upper limits" as follows: The confidence level associated with a given upper limit N and an observed value n_0 of n is the probability that $n > n_0$ if $\bar{n} = N$, i. e.,

$$CL = \sum_{n=n_0+1}^{\infty} P_N(n) = 1 - \sum_{n=0}^{n_0} P_N(n) \tag{8}$$



[The small figure in Eq. (8) is drawn with $n_0 = 2$ and CL = 90%.] A useful relation between Poisson and chi-squared confidence levels allows one to look up this quantity on the above figure. Specifically, the quantity 1-CL is given by the ordinate of the $n_D = 2(n_0+1)$ curve at $\chi^2 = 2N$. Thus, 90% confidence level upper limits for n_0 = 0, 1, and 2 are given by half the χ^2 value corresponding to an ordinate of 0.1 on the n_D = 2, 4, and 6 curves, respectively; the values are N = 2.3, 3.9, and 5.3.

- -

Tables of confidence levels for all three of these distributions, the relation between Poisson and chi-squared confidence levels, and numerous other useful tables and relations may be found in Ref. 2.

B. STATISTICS

We consider here the situation in which one is presented with N independent data, $y_n \pm \sigma_n$, and it is desired to make some inference about the "true" value of the quantity represented by these data. For this purpose we interpret each datum y_n as a single sample point drawn randomly (and independently of the other data) from a distribution having mean $\bar{y}_n$ (which we wish to estimate) and variance σ_n^2. (Identification of the true σ_n with the σ_n datum is an approximation which may become seriously inaccurate when σ_n is an appreciable fraction of y_n.) Some methods of estimation commonly used in high energy physics are given below; see Ref. 3 for numerous applications. Section B.1. deals with the case in which all $\bar{y}_n$ are the same, e. g., several different measurements of the same quantity; Sec. B.2. deals with the case in which $\bar{y}_n = \bar{y}(x_n)$, where x_n represents some set of independent variables, e. g., cross-section measurements at various values of energy and angle, $x_n = \{E_n, \theta_n\}$.

B.1. Single Mean and Variance Estimates

(1) If the y_n represent a set of values all supposedly drawn from a single distribution with mean $\bar{y}$ and variance σ^2 (i. e., the σ_n are all the same, but their common value is unknown) then

$$\bar{y}_e = \frac{1}{N} \sum_n y_n \quad \text{and} \tag{9}$$

$$\sigma_e^2 = \frac{1}{N-1} \sum_n (y_n - \bar{y}_e)^2 = \frac{N}{N-1}\left[\left(\overline{y^2}\right)_e - \bar{y}_e^2\right] \tag{10}$$

are unbiased estimates of $\bar{y}$ and σ^2. The variance of $\bar{y}_e$ is σ^2/N. If the parent distribution is normal and N is large, the variance of σ_e^2 is $2\sigma^4/N$.

(2) If the $\bar{y}_n$ all have the common value $\bar{y}$ and the σ_n are known, then the weighted average

$$\bar{y}_e = \frac{1}{w} \sum_n w_n y_n , \tag{11}$$

where $w_n = 1/\sigma_n^2$ and $w = \Sigma w_n$, is an appropriate unbiased estimate of $\bar{y}$. This choice of weighting factors in Eq. (11) minimizes the variance of the estimate; the variance is 1/w.

B.2. Linear Least Squares Fit

A least squares fit of the function $y(x) = \Sigma_i a_i f_i(x)$ to independent data $y_n \pm \sigma_n$ at points x_n (e. g., a Legendre fit in which the f_i are Legendre polynomials and the a_i are Legendre coefficients) gives the following estimates of the parameters a_i:

$$a_{e,i} = \sum_{j,n} V_{ij} f_j(x_n) y_n/\sigma_n^2 . \tag{12}$$

Here V is the covariance matrix of the fitted parameters

$$V_{ij} = \overline{(a_{e,i} - \bar{a}_{e,i})(a_{e,j} - \bar{a}_{e,j})} , \tag{13}$$

which is given by

$$(V^{-1})_{ij} = \sum_n f_i(x_n) f_j(x_n)/\sigma_n^2 . \tag{14}$$

The variance of an interpolated or extrapolated value of y at point x, $y_e = \Sigma a_{e,i} f_i(x)$, is:

$$\overline{(y_e - \bar{y}_e)^2} = \sum_{ij} V_{ij} f_i(x) f_j(x) . \tag{15}$$

For the case of a straight line fit, y(x) = a + bx, one obtains the following estimates of a and b,

$$a_e = (S_y S_{xx} - S_x S_{xy})/D, \quad b_e = (S_1 S_{xy} - S_x S_y)/D, \tag{16}$$

where

$$S_1, S_x, S_y, S_{xx}, S_{xy} = \Sigma (1, x_n, y_n, x_n^2, x_n y_n)/\sigma_n^2, \quad D = S_1 S_{xx} - S_x^2 . \tag{17}$$

The covariance matrix of the fitted parameters is:

$$\begin{pmatrix} V_{aa} & V_{ab} \\ V_{ab} & V_{bb} \end{pmatrix} = \frac{1}{D}\begin{pmatrix} S_{xx} & -S_x \\ -S_x & S_1 \end{pmatrix} \tag{18}$$

The variance of an interpolated or extrapolated value of y at point x is:

$$\overline{(y_e - \bar{y}_e)^2} = \frac{1}{S_1} + \frac{S_1}{D}\left(x - \frac{S_x}{S_1}\right)^2 \tag{19}$$

C. ERROR PROPAGATION

We consider here the situation in which one wishes to calculate the value and error of a function of some other quantities with errors, e. g., in a Monte Carlo program. Let {y} be a set of random variables with means $\{\bar{y}\}$ and covariance matrix V. Then the mean and variance of a function of these variables are approximately (to second order in $\{y-\bar{y}\}$):

$$\bar{f} \approx f(\{y\}) + \frac{1}{2} \sum_{mn} V_{mn} \left(\frac{\partial^2 f}{\partial y_m \partial y_n}\right)_{\{y\} = \{\bar{y}\}} , \tag{20}$$

$$\overline{(f - \bar{f})^2} = \sum_{mn} V_{mn} \left(\frac{\partial f}{\partial y_m}\right)_{\{y\} = \{\bar{y}\}} \left(\frac{\partial f}{\partial y_n}\right)_{\{y\} = \{\bar{y}\}} . \tag{21}$$

E. g., the mean and variance of a function of a single variable with mean $\bar{y}$ and variance σ^2 are:

$$\bar{f} \approx f(\bar{y}) + \frac{1}{2}\sigma^2 f''(\bar{y}), \tag{22}$$

$$\overline{(f - \bar{f})^2} = \sigma^2 f'(\bar{y})^2 . \tag{23}$$

Note that these equations will usually be applied by substituting some measured quantities, $\{\tilde{y}\}$ say, for the true means, $\{\bar{y}\}$. If, as is often the case, $\tilde{y}_n - \bar{y}_n$ is of order $\sqrt{V_{nn}}$, then there is no point in keeping the second order terms in Eq. (20) or (22) since the substitution itself introduces first order errors.

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1. R. A. Fisher, Statistical Methods for Research Workers (Oliver and Boyd, Edinburgh and London, 1958).
2. M. Abramovitz and I. Stegun, eds., Handbook of Mathematical Functions (National Bureau of Standards, Applied Mathematics Series, Vol. 55, Washington, 1964).
3. W. T. Eadie, D. Drijard, F. E. James, M. Roos, and B. Sadoulet, Statistical Methods in Experimental Physics (North-Holland, Amsterdam and London, 1971).

Revised and expanded April 1974.

RELATIVISTIC KINEMATICS

I. BASICS

(a) Lorentz transformations -- Let E and $\vec{p}$ be the energy and 3-momentum of a particle or system as seen from a certain inertial frame, and let E^* and $\vec{p}^*$ be the same quantities as seen from a second inertial frame that moves with velocity $\vec{\beta}$ relative to the first. Then starred and unstarred quantities are related by

$$\begin{pmatrix} E^* \\ p^*_\parallel \end{pmatrix} = \begin{pmatrix} \gamma & -\gamma\beta \\ -\gamma\beta & \gamma \end{pmatrix} \begin{pmatrix} E \\ p_\parallel \end{pmatrix}, \quad p^*_\perp = p_\perp .$$

Here $\gamma = (1-\beta^2)^{-1/2}$, and subscripts $\parallel$ and $\perp$ indicate components of $\vec{p}$ or $\vec{p}^*$ that are parallel or perpendicular to $\vec{\beta}$ (often η is used for $\gamma\beta$). The inverse transformation is given by changing β to $-\beta$. A particle of mass m at rest in the second frame, so that it is moving at velocity $\vec{\beta}$ relative to the first, has $E^* = m$ and $\vec{p}^* = 0$, so here

$$E = \gamma m, \quad \vec{p} = \gamma\vec{\beta}m .$$

In any frame, the energy, momentum, and mass are related by

$$E^2 = p^2 + m^2 .$$

(b) Four momenta; scalar products -- The 4-momentum vector of a particle or system having energy E and 3-momentum $\vec{p}$ is

$$q = (E, \vec{p}) = (E, p_x, p_y, p_z) .$$

Conservation of energy and the components of 3-momentum for any process a + b + ... → 1 + 2 + ... may then be written as

$$q_a + q_b + \ldots = q_1 + q_2 + \ldots .$$

Although the components of a 4-momentum are different in different frames, the scalar product of any two 4-momenta q and q', defined as

$$q \cdot q' = EE' - \vec{p}\cdot\vec{p}' ,$$

is an invariant; i.e., in numerical calculations the same result is obtained in any frame, and in algebraic calculations results obtained in different frames may be equated. For a particle of mass m, the scalar product q·q is

$$q\cdot q = q^2 = E^2 - \vec{p}^2 = m^2 .$$

The invariant mass M (or total c.m. energy) of an n-particle system is given by

$$M^2 = \Big(\sum_{i=1}^{n} q_i\Big)^2 = \Big(\sum_i E_i\Big)^2 - \Big(\sum_i \vec{p}_i\Big)^2 ,$$

where $q_i = (E_i, \vec{p}_i)$ is the 4-momentum of the i^{th} particle.

(c) Electric and magnetic forces -- In Gaussian cgs units, the force on a particle with charge q moving with velocity $\vec{v}$ in electric and magnetic fields $\vec{E}$ and $\vec{B}$ is

$$\vec{F} = q\vec{E} + q\vec{\beta}\times\vec{B} ,$$

where $\vec{\beta} = \vec{v}/c$. The units are $\vec{F}$ in dynes, q in esu, $\vec{E}$ in statvolts/cm, and $\vec{B}$ in gauss. In mksa units, the force is

$$\vec{F} = q\vec{E} + q\vec{v}\times\vec{B} ,$$

where the units are $\vec{F}$ in newtons (1 N = 10^5 dynes), q in coulombs (1 C ≃ 3×10^9 esu; each 3 in this section is really 2.9979...), $\vec{E}$ in volts/m (1 V ≃ 1/300 statvolt), and $\vec{B}$ in tesla (1 T = 10^4 G). The force is zero if $\vec{E}$ and $\vec{B}$ are at right angles, $\vec{\beta}$ (or $\vec{v}$) is in the direction $\vec{E}\times\vec{B}$, and $\beta = E/B$ (cgs) or $v = E/B$ (mksa).

In a uniform, static magnetic field, the path of a charged particle is a helix of constant radius R and constant pitch angle λ, with the axis of the helix being along $\vec{B}$. The momentum is related to the other quantities by

$$p\cos\lambda \simeq 3\times10^{-4}\, qBR ,$$

where the units (very mixed!) are p in GeV/c, q in multiples of the electronic charge e, B in kG, and R in cm. The angular velocity about the axis of the helix is

$$\omega \simeq 3\times10^{-4}\, qB/\gamma m ,$$

where the units are ω in rad/sec, q in multiples of the electronic charge e, B in kG, and the energy γm in GeV.

II. DECAYS

(a) Survival probabilities -- Let a particle have mass m and proper mean life τ_0. In a frame in which its 4-momentum is $(E, \vec{p})$, the probability that it survives a time greater than t before decaying is

$$\text{Prob.}(>t) = \exp(-t/\gamma\tau_0) = \exp(-mt/E\tau_0) .$$

The probability that it goes a distance greater than x before decaying is

$$\text{Prob.}(>x) = \exp(-x/\gamma\beta c\tau_0) = \exp(-mx/pc\tau_0) ;$$

values of $c\tau_0$ (in cm) are given in the Stable Particle Table. If the particle has charge ±e and is in a uniform magnetic field $\vec{B}$ [see I(c)], then the probability that the projection of its helical path on the plane perpendicular to $\vec{B}$ turns through an angle greater than θ before decaying is

$$\text{Prob.}(>\theta) = \exp(-Cm\theta/B\tau_0) ,$$

where, if m is in GeV, θ in deg, B in kG, and τ_0 in sec, then C is numerically 1.942×10^{-9}. This last distribution is independent of p or the helical pitch angle λ; its only dependence is geometrical.

(b) Two-body decays -- A particle of mass m decays into two particles, masses m_1 and m_2. In the rest frame of m, the energies of m_1 and m_2 are

$$\epsilon_1 = (m^2 + m_1^2 - m_2^2)/2m$$
$$\epsilon_2 = (m^2 + m_2^2 - m_1^2)/2m .$$

In this frame, the 3-momenta of m_1 and m_2 are equal and opposite and of magnitude

$$k = (\epsilon_1^2 - m_1^2)^{1/2} = (\epsilon_2^2 - m_2^2)^{1/2}$$
$$= \{[m^2 - (m_1+m_2)^2]\,[m^2 - (m_1-m_2)^2]\}^{1/2}/2m .$$

See also the third paragraph of III(b).

(c) Three-body decays -- A particle of mass m decays into three particles, masses m_1, m_2, and m_3. The invariant masses m_{ij} of the 2-particle systems, where $m_{ij}^2 = (q_i + q_j)^2$, satisfy the relation

$$m_{12}^2 + m_{13}^2 + m_{23}^2 = m^2 + m_1^2 + m_2^2 + m_3^2 ,$$

so that only two of the three m_{ij}'s are independent. In a rectangular Dalitz plot, m_{13}^2 (say) is plotted against m_{12}^2. The kinematic boundaries may be calculated as follows: (i) The lower and upper limits on m_{12}^2 are $(m_1+m_2)^2$ and $(m-m_3)^2$. (ii) For any m_{12}^2 between these limits, the lower and upper limits on m_{13}^2 are given by taking the + and − signs in

$$m_{13}^2 = (E_1 + E_3)^2 - (p_1 \pm p_3)^2 ,$$

where

$$E_1 = (m_{12}^2 + m_1^2 - m_2^2)/2m_{12}$$
$$E_3 = (m^2 - m_{12}^2 - m_3^2)/2m_{12}$$
$$p_1 = (E_1^2 - m_1^2)^{1/2}$$
$$p_3 = (E_3^2 - m_3^2)^{1/2} .$$

(These are the energies and momenta of particles 1 and 3 in the rest frame of m_{12}.) The phase-space density is uniform over the areas of both the above and the following form of the Dalitz plot.

In a triangular Dalitz plot, the kinetic energies T_1, T_2, and T_3 of the final-state particles in the rest frame of m are plotted as the distances inward from the sides of an equilateral triangle whose altitude is the energy Q released by the decay:

$$Q = T_1 + T_2 + T_3 = m - m_1 - m_2 - m_3 .$$

The kinetic energies are related to the 2-particle invariant masses by

$$2mT_1 = (m - m_1)^2 - m_{23}^2 = (m_{23}^{max})^2 - m_{23}^2 ,$$

etc.

RELATIVISTIC KINEMATICS (Cont'd)

(d) Four–body decays -- A particle of mass m decays into four particles, masses m_1, m_2, m_3, and m_4. In a triangle (or Goldhaber) plot, the invariant mass of two of the particles is plotted against that of the other two, say m_{34} versus m_{12}, where $m_{ij}^2 = (q_i + q_j)^2$. The kinematic boundaries of this plot are the sides of the triangle whose vertices are at the points $(m_{12}, m_{34}) = (m_1 + m_2, m_3 + m_4)$, $(m_1 + m_2, m - m_1 - m_2)$, and $(m - m_3 - m_4, m_3 + m_4)$. The phase–space density is not uniform over the enclosed area.

III. REACTIONS (MAINLY 2–BODY)

(a) Initial state -- Two particles, masses m_1 and m_2, interact. In the lab frame, where particle 2 is at rest, the 4–momenta are $(E_1, \vec{p}_1)$ and $(m_2, 0)$. In the c.m. frame, where the 3–momenta are equal and opposite, the 4–momenta are $(\epsilon_1, \vec{k})$ and $(\epsilon_2, -\vec{k})$. Then the total c.m. energy E is given by

$$E^2 = (\epsilon_1 + \epsilon_2)^2 = m_1^2 + m_2^2 + 2E_1m_2 .$$

The c.m. energies of particles 1 and 2 are

$$\epsilon_1 = (m_1^2 + E_1m_2)/E = (E^2 + m_1^2 - m_2^2)/2E$$

$$\epsilon_2 = (m_2^2 + E_1m_2)/E = (E^2 + m_2^2 - m_1^2)/2E .$$

The c.m. momentum k is

$$k = p_1m_2/E .$$

See also the expression in II(b) for k, in which replace m with E.

The velocity of the c.m. relative to the lab is

$$\beta = p_1/(E_1 + m_2) .$$

The parameters for the Lorentz transformation between these frames [see I(a)] are

$$\gamma = (E_1 + m_2)/E$$

and

$$\gamma\beta = p_1/E .$$

(b) Two–body final states -- In the reaction $1 + 2 \to 3 + 4$, let the masses be m_i and the final–state c.m. 4–momenta be $(\epsilon_3, \vec{k}')$ and $(\epsilon_4, -\vec{k}')$. Then

$$\epsilon_3 = (E^2 + m_3^2 - m_4^2)/2E$$

$$\epsilon_4 = (E^2 + m_4^2 - m_3^2)/2E ;$$

and

$$k' = (\epsilon_3^2 - m_3^2)^{1/2} = (\epsilon_4^2 - m_4^2)^{1/2}$$

$$= \{[E^2 - (m_3 + m_4)^2]\,[E^2 - (m_3 - m_4)^2]\}^{1/2}/2E .$$

Let Θ_3 be the lab production angle of particle 3 (the angle between $\vec{p}_3$ and $\vec{p}_1$), and let θ_3 be the c.m. production angle (the angle between $\vec{k}'$ and $\vec{k}$). These angles are related by

$$\tan\Theta_3 = \frac{p_{3\perp}}{p_{3\parallel}} = \frac{\sin\theta_3}{\gamma(\cos\theta_3 + \beta/\beta_3)} ,$$

where $p_{3\perp}$ and $p_{3\parallel}$ are the components of $\vec{p}_3$ perpendicular and parallel to $\vec{p}_1$, and $\beta_3 = k'/\epsilon_3$ is the c.m. velocity of particle 3. [See III(a) for γ and β.] If $\beta > \beta_3$, then particle 3 can only go forward in the lab, the maximum Θ_3 being given by

$$\tan\Theta_3^{max} = \beta_3\left(\frac{1-\beta^2}{\beta^2-\beta_3^2}\right)^{1/2} .$$

The components of $\vec{p}_3$ satisfy

$$\left(\frac{p_{3\parallel} - \gamma\beta\epsilon_3}{\gamma k'}\right)^2 + \left(\frac{p_{3\perp}}{k'}\right)^2 = 1 ,$$

which is the equation of an ellipse with semi–major axis $\gamma k'$ and semi–minor axis k'. Thus the possible lab momenta of particle 3 are the vectors to the ellipse from the point a distance $\gamma\beta\epsilon_3$ back along the major axis from the center of the ellipse.

The results of the preceding paragraph also apply to 2–body decay. Just set $m_2 = 0$, in which case $E = m_1$. [The decay–product masses are here m_3 and m_4, not m_1 and m_2 as in II(b).]

The Mandelstam variables s, t, and u are the Lorentz scalars defined in terms of the particle 4–momenta q_i as

$$s = (q_1 + q_2)^2 = (q_3 + q_4)^2$$

$$t = (q_1 - q_3)^2 = (q_2 - q_4)^2$$

$$u = (q_1 - q_4)^2 = (q_2 - q_3)^2 .$$

They satisfy the relation

$$s + t + u = m_1^2 + m_2^2 + m_3^2 + m_4^2 ,$$

so that only two of the three are independent. Evaluating s in the c.m. frame gives

$$s = (\epsilon_1 + \epsilon_2)^2 = E^2 ,$$

and evaluating t and u, the 4–momentum–transfer–squared variables, in this frame gives

$$t = m_1^2 + m_3^2 - 2\epsilon_1\epsilon_3 + 2kk'\cos\theta_3$$

$$= t_0 - 4kk'\sin^2(\theta_3/2)$$

$$u = m_1^2 + m_4^2 - 2\epsilon_1\epsilon_4 + 2kk'\cos\theta_4$$

$$= u_0 - 4kk'\sin^2(\theta_4/2) ,$$

where θ_4 is the c.m. production angle of particle 4 ($\theta_3 + \theta_4 = \pi$), and

$$t_0 = t(\theta_3 = 0) = (\epsilon_1 - \epsilon_3)^2 - (k - k')^2$$

$$u_0 = u(\theta_4 = 0) = (\epsilon_1 - \epsilon_4)^2 - (k - k')^2 .$$

The differences $\Delta t = t_0 - t_\pi$ and $\Delta u = u_0 - u_\pi$, where $t_\pi = t(\theta_3 = \pi)$ and $u_\pi = u(\theta_4 = \pi)$, are

$$\Delta t = \Delta u = 4kk' .$$

For elastic scattering, where $m_1 = m_3 = m$ and $m_2 = m_4 = M$, t_0 is zero and

$$t = -2k^2(1 - \cos\theta_3) = -4k^2\sin^2(\theta_3/2) .$$

And now

$$u_0 = (m^2 - M^2)^2/s .$$

Evaluating t in the lab frame gives

$$t = -2MT_4 ,$$

where $T_4 = E_4 - M$ is the lab kinetic energy of particle 4. For small–angle elastic scattering,

$$(-t)^{1/2} \approx k\theta_3 \approx p_1\Theta_3 \approx p_4 ,$$

where p_1, Θ_3, and p_4 are lab quantities.

IV. OTHER VARIABLES

(a) Rapidity -- For a system of energy E and momentum $\vec{p}$, the rapidity y is given by

$$y = \frac{1}{2}\ln\left(\frac{E+p_\parallel}{E-p_\parallel}\right) = \tanh^{-1}\left(\frac{p_\parallel}{E}\right) = \ln\left(\frac{E+p_\parallel}{m_\perp}\right) ,$$

where $p_\parallel$ is the component of $\vec{p}$ along a particular axis (the "rapidity axis", chosen, for example, parallel to the direction of an incoming beam), and $m_\perp = (m^2 + p_\perp^2)^{1/2}$. Inverting these equations, we find

$$E = m_\perp\cosh y$$

$$p_\parallel = m_\perp\sinh y .$$

The shape of a rapidity distribution is invariant under a Lorentz transformation between inertial frames with relative motion parallel to the rapidity axis. Such a transformation is given by

$$y^* = y - \ln[\gamma(1+\beta)] = y - \frac{1}{2}\ln\left(\frac{1+\beta}{1-\beta}\right) ,$$

where the sign of β is positive in the direction of increasing rapidity and $p_\parallel$.

RELATIVISTIC KINEMATICS (Cont'd)

(b) Scaling variable, hadron reactions -- In the inclusive reaction h + 2 → 3 + X, with h any hadron, Feynman's x for particle 3 is defined as

$$x = k'_{\parallel}/k'_{max} ,$$

where k' is the c.m. momentum of particle 3. k'_{max} is obtained [see Sec. III(b)] using the smallest mass m_X [called m_4 in III(b)] consistent with quantum conservation laws. At high energies, $k'_{max} \simeq \sqrt{s}/2$. Rapidity and x are related at large $\sqrt{s}$ by

$$x \simeq \frac{2m_{\perp}}{\sqrt{s}} \sinh y^* ,$$

where y^* is evaluated in the c.m.

(c) Scaling variables, lepton reactions -- For the inclusive reaction $\ell + 2 \to \ell' + X$, with particles ℓ and ℓ' leptons, we define the 4-vector

$$q = (p_\ell - p_{\ell'})$$

so that

$$Q^2 \equiv -q^2 = 2E_\ell E_{\ell'} - 2|\vec{p}_\ell||\vec{p}_{\ell'}| \cos\theta - m^2_{\ell'} - m^2_\ell \gtrsim^{\dagger} 0$$

where θ is the $\ell \to \ell'$ scattering angle, and the preceding relation is valid in any frame. Also useful are

$$\nu = p_2 \cdot q/m_2 = [\, E_\ell - E_{\ell'} \,]_{LAB} = [\, E_X - m_2 \,]_{LAB}$$

and

$$W = \sqrt{p_X^2} = (-Q^2 + 2m_2\nu + m_2^2)^{1/2} = m_X .$$

Q^2, ν, and W are Lorentz invariants, and the notation "LAB" refers to the reference frame with particle 2 at rest. (Note: ν is sometimes written $\nu = p_2 \cdot q$, leading to the replacement of $m_2\nu$ with ν throughout.)

Scaling variables in common use include

$$x \equiv \omega^{-1} = Q^2/2m_2\nu , \; 0 \lesssim^{\dagger} x \lesssim^{\dagger} 1$$

and

$$y = m_2\nu/p_\ell \cdot p_2 = [\, (E_\ell - E_{\ell'})/E_\ell \,]_{LAB} , \; 0 \lesssim^{\dagger} y \leq 1 .$$

Both x and y are dimensionless.

Cross sections for inclusive reactions in the energy region where masses are negligible can be written in terms of E_ℓ and certain pairs of these variables, usually Q^2 and ν, x and y, or Q^2 and x. If, in any frame, $|\vec{p}_\ell||\vec{p}_{\ell'}| \simeq E_\ell E_{\ell'}$ and $E_\ell E_{\ell'} \sin^2(\theta/2) >> m^2_{\ell'}$ and m^2_ℓ (i.e., m_ℓ, $m_{\ell'}$ small), then

$$Q^2 \simeq 4E_\ell E_{\ell'} \sin^2(\theta/2)$$

and

$$x \simeq \frac{2E_\ell E_{\ell'} \sin^2(\theta/2)}{m_2\nu} .$$

†Inequality sometimes violated unless $m_X \geq m_2$ and $m_{\ell'} \geq m_\ell$.

LORENTZ INVARIANT PHASE SPACE FORMULAE

For a system of n particles with overall four-momentum p and final four momenta $p_1, \cdots, p_n [p_i = (E_i, \vec{P}_i)]$, Lorentz Invariant Phase Space is given by

$$d\,\mathrm{LIPS}(s;p_1,\cdots,p_n) = (2\pi)^4 \delta^4(p - \sum_i p_i) \frac{1}{(2\pi)^{3n}} \prod_{i=1}^{n} \frac{d^3\vec{P}_i}{2E_i} . \quad (1)$$

For 2-body: $$d\,\mathrm{LIPS}(s,p_1,p_2) = \frac{1}{(2\pi)^2} \delta^4(p-p_1-p_2)\, d^4p \frac{|\vec{P}_1^{cm}|}{4\sqrt{s}} d\Omega_1^{cm} . \quad (2)$$

For 3-body: $$d\,\mathrm{LIPS}(s,p_1,p_2,p_3) = \frac{1}{(2\pi)^5} \delta^4(p-p_1-p_2-p_3) d^4p \frac{1}{32s} ds_{12} ds_{23} d\alpha d\cos\beta d\gamma , \quad (3)$$

where α, β, and γ are Euler angles.

For a + b → n particles or X → n particles, in general $|i\rangle \to |f\rangle$,

$$\sigma_{if} = \frac{1}{4F} \int |\mathcal{M}_{if}|^2 \; d\,\mathrm{LIPS}(s;p_1,\cdots,p_n), \quad (4)$$

or

$$\Gamma_{if} = \frac{1}{2m_X} \int |\mathcal{M}_{if}|^2 \; d\,\mathrm{LIPS}(m_X^2;\, p_1,\cdots,p_n), \quad (5)$$

where $\mathcal{M}_{if}$ is an invariant matrix element. F is Møller's invariant flux factor, $F^2 = (p_a \cdot p_b)^2 - m_a^2 m_b^2$. If a is beam, b, target ($\vec{P}_b^{lab} = 0$), then $F = |\vec{P}_a^{lab}|\, m_b = |\vec{P}_a^{cm}|\sqrt{s}$.

For elastic scattering in c.m., $|\vec{P}_a^{cm}| = |\vec{P}_1^{cm}|$, and (2) and (4) yield

$$\frac{d\sigma}{d\Omega} = \frac{|\mathcal{M}|^2}{(8\pi)^2 s} \quad \text{or} \quad \frac{d\sigma}{dt} = \frac{|\mathcal{M}|^2}{64\pi |\vec{P}_a^{cm}|^2 s} . \quad (6)$$

The normalization is such that the optical theorem reads

$$\mathrm{Im}\, \mathcal{M}|_{t=0} = 2|\vec{P}_a^{cm}|\sqrt{s}\, \sigma_{tot} . \quad (7)$$

The choice of Eq. (1) implies a particular normalization of any spinors that may occur in $\mathcal{M}$. The advantage of this normalization is that it greatly simplifies the structure of $\mathcal{M}$ by putting factors such as $\frac{1}{(2\pi)^3}\, \frac{1}{2E}$ into the phase space where they really belong. In addition, the labels, i, f, refer to specific spin (helicity) states, so that the usual "average and sum" rule is implicit.

WEAK INTERACTIONS OF QUARKS AND LEPTONS

The "standard" SU(2) ⊗ U(1) model[1,2] is described here for six quarks and six leptons in left-handed doublets of $SU(2)_{weak}$ and right-handed singlets of $SU(2)_{weak}$ (T_3 = third component of weak isospin):

$$\begin{matrix} T_3=+1/2 \\ T_3=-1/2 \end{matrix} \quad \begin{pmatrix} \nu_e \\ e^- \end{pmatrix}_L \begin{pmatrix} \nu_\mu \\ \mu^- \end{pmatrix}_L \begin{pmatrix} \nu_\tau \\ \tau^- \end{pmatrix}_L \begin{pmatrix} u \\ d' \end{pmatrix}_L \begin{pmatrix} c \\ s' \end{pmatrix}_L \begin{pmatrix} t \\ b' \end{pmatrix}_L ,$$

$$T = T_3 = 0 \quad e_R^- \quad \mu_R^- \quad \tau_R^- \quad u_R \quad d_R \quad c_R \quad s_R \quad t_R \quad b_R .$$

Mixing occurs between quarks d, s, b of charge −1/3 (by convention the charge 2/3 quarks, u, c, t, are unmixed) and is expressed by the Kobayashi-Maskawa (KM) mixing matrix[2]

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} c_1 & s_1c_3 & s_1s_3 \\ -s_1c_2 & c_1c_2c_3+s_2s_3e^{i\delta} & c_1c_2s_3-s_2c_3e^{i\delta} \\ -s_1s_2 & c_1s_2c_3-c_2s_3e^{i\delta} & c_1s_2s_3+c_2c_3e^{i\delta} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix},$$

where $c_i = \cos\theta_i$, $s_i = \sin\theta_i$, $i=1,2,3$. In the limit $\theta_2=\theta_3=\delta=0$, this reduces to the usual Cabibbo mixing with θ_1 the Cabibbo angle.

The interaction Lagrangian is

$$\mathcal{L}_{int} = e\left[A^\alpha J_\alpha^{em} + \frac{1}{\sin\theta_W\cos\theta_W} Z^\alpha J_\alpha^N + \frac{1}{\sqrt{2}\,\sin\theta_W}\left(W^{+\alpha} J_\alpha^C + W^{-\alpha} J_\alpha^{C\dagger}\right)\right]$$

Here θ_W is the weak mixing angle in the relations

$$W^0 = Z\cos\theta_W + A\sin\theta_W$$

$$B = -Z\sin\theta_W + A\cos\theta_W$$

which relate the physical fields A (photon) and Z (neutral weak gauge boson) to W^0 ($SU(2)_{weak}$ partner of W^+ and W^-) and B (U(1) gauge field). The charged current is written

$$J_\alpha^C = (\bar\nu_e\ \bar\nu_\mu\ \bar\nu_\tau)\left[\gamma_\alpha \frac{(1-\gamma_5)}{2}\right]\begin{pmatrix} e^- \\ \mu^- \\ \tau^- \end{pmatrix} + (\bar u\ \bar c\ \bar t)\left[\gamma_\alpha \frac{(1-\gamma_5)}{2}\right]\begin{pmatrix} \text{KM} \\ \text{mixing} \\ \text{matrix} \end{pmatrix}\begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

i.e., V-A structure. The neutral current is written

$$J_\alpha^N = (\bar\nu_e\ \bar\nu_\mu\ \bar\nu_\tau)\left[\frac{1}{2}\gamma_\alpha\frac{(1-\gamma_5)}{2}\right]\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix}$$

$$+ (\bar e\ \bar\mu\ \bar\tau)\left[-\frac{1}{2}\gamma_\alpha\frac{(1-\gamma_5)}{2} + \sin^2\theta_W\,\gamma_\alpha\right]\begin{pmatrix} e \\ \mu \\ \tau \end{pmatrix}$$

$$+ (\bar u\ \bar c\ \bar t)\left[\frac{1}{2}\gamma_\alpha\frac{(1-\gamma_5)}{2} - \frac{2}{3}\sin^2\theta_W\,\gamma_\alpha\right]\begin{pmatrix} u \\ c \\ t \end{pmatrix}$$

$$+ (\bar d\ \bar s\ \bar b)\left[-\frac{1}{2}\gamma_\alpha\frac{(1-\gamma_5)}{2} + \frac{1}{3}\sin^2\theta_W\,\gamma_\alpha\right]\begin{pmatrix} d \\ s \\ b \end{pmatrix},$$

where for fermion f the coupling $[\Gamma_\alpha^f]$ has a V-A term depending on T_3^f and a vector term depending on charge Q_f:

$$\left[\Gamma_\alpha^f\right] = \left[T_3^f\,\gamma_\alpha\frac{(1-\gamma_5)}{2} - Q_f\sin^2\theta_W\,\gamma_\alpha\right].$$

The effective Lagrangian for exchange of $W^\pm$ and Z between two currents reduces at low q^2 to

$$\mathcal{L}_{weak} = \frac{G}{\sqrt{2}}\,4\left(J^{C\alpha}J_\alpha^{C\dagger} + 2\rho J^{N\alpha}J_\alpha^N\right)$$

with $G/\sqrt{2} = \pi\alpha/(2M_W^2\sin^2\theta_W)$, $\alpha = e^2/(4\pi)$, and $\rho = M_W^2/(M_Z^2\cos^2\theta_W)$. Assuming the simplest Higgs structure, ρ=1, and the W and Z masses are related by $M_Z = M_W/\cos\theta_W$. Currently reported values of the weak interaction parameters are

$\lvert\cos\theta_1\rvert = 0.9737 \pm 0.0025$ $\lvert\sin\theta_1\cos\theta_3\rvert = 0.219 \pm 0.011$	Ref. 3 ;
$\lvert\sin\theta_1\sin\theta_3\rvert = 0.06 \pm 0.06$	Refs. 3,4 ;
θ_2 and δ not determined without additional theoretical input	Ref. 5 ;
$G = G_\mu = (1.16632 \pm 0.00004)\times10^{-5}\ \text{GeV}^{-2}$	Refs. 3,6 ;
$\sin^2\theta_W = 0.218 \pm 0.025$, $\rho = 0.985 \pm 0.026$ $\sin^2\theta_W = 0.228 \pm 0.010$, $\rho \equiv 1$ (fixed)	Ref. 7 .

The resulting mass estimates for $W^\pm$ and Z are $M_W = 37.3\ \text{GeV}/\sin\theta_W = 78.1 \pm 1.7$ GeV, and $M_Z = 88.9 \pm 1.4$ GeV, where the numerical values are obtained using the simplest Higgs structure ($\rho\equiv1$).

Lepton-Nucleon Inclusive Scattering

For reactions $\ell+N \to \ell'+X$, differential cross sections can be written using several choices of independent variables. These are related by

$$\frac{d^2\sigma}{dxdy} = 2ME_\ell^2 y\frac{d^2\sigma}{d\nu dQ^2} = 2ME_\ell x\frac{d^2\sigma}{dxdQ^2} = \frac{2\pi ME_\ell^2 y}{|\vec p_\ell|\,|\vec p_{\ell'}|}\frac{d^2\sigma}{d\Omega dE_{\ell'}}$$

$$\cong \frac{2\pi ME_\ell y}{E_{\ell'}}\frac{d^2\sigma}{d\Omega dE_{\ell'}},$$

where ν, Q^2, x, and y are defined in the Relativistic Kinematics section IV(c), E_ℓ, $\vec p_\ell$ and $E_{\ell'}$, $\vec p_{\ell'}$ are the incident and outgoing lepton lab energies and momenta, and M is the target nucleon mass.

Structure Functions[8,9]

For charged current (C.C.) and neutral current (N.C.) reactions, we have

$$\frac{d^2\sigma^{\nu(\bar\nu)}}{dxdy} = \frac{G^2ME_\ell}{\pi}\left[\left(1-y-\frac{M}{2E_\ell}xy\right)F_2^{\nu(\bar\nu)}(x,Q^2) + \frac{y^2}{2}\,2xF_1^{\nu(\bar\nu)}(x,Q^2) \pm\left(y-\frac{y^2}{2}\right)xF_3^{\nu(\bar\nu)}(x,Q^2)\right],$$

where the upper and lower signs refer to ν and $\bar\nu$ scattering, respectively, and F_3 is defined as a positive quantity. The other common structure functions W_i are related by $MW_1 = F_1$, $\nu W_2 = F_2$, and $\nu W_3 = -F_3$. For electron and muon scattering, $F_3=0$, and G^2 is replaced by $8\pi^2\alpha^2/(Q^2)^2$.

WEAK INTERACTIONS OF QUARKS AND LEPTONS (Cont'd)

The ratio of the longitudinally to transversely polarized photon absorption cross section is

$$R = \frac{\sigma_L}{\sigma_T} = \frac{1}{2xF_1(x,Q^2)}\left[F_2(x,Q^2) - 2xF_1(x,Q^2) + \frac{4M^2x^2}{Q^2}F_2(x,Q^2)\right] .$$

To compare with the parton-model predictions below, we write for $E_\ell >> M$:

$$\frac{d^2\sigma^{\nu(\bar\nu)}}{dxdy} = \frac{G^2ME_\ell}{\pi}\left[\frac{1}{2}\left(2xF_1^{\nu(\bar\nu)} \pm xF_3^{\nu(\bar\nu)}\right) + \frac{1}{2}(1-y)^2\left(2xF_1^{\nu(\bar\nu)} \mp xF_3^{\nu(\bar\nu)}\right) + (1-y)\left(F_2^{\nu(\bar\nu)} - 2xF_1^{\nu(\bar\nu)}\right)\right],$$

$$\frac{d^2\sigma^{e,\mu}}{dxdy} = \frac{8\pi\alpha^2ME_\ell}{(Q^2)^2}\left[\frac{1+(1-y)^2}{2}\,2xF_1^{e,\mu} + (1-y)\left(F_2^{e,\mu} - 2xF_1^{e,\mu}\right)\right].$$

The Free-Quark-Parton-Model Predictions[10]

For this model in the Bjorken limit ($Q^2,\nu\to\infty$ with x fixed), $F_i(x,Q^2) \to F_i(x)$.[8,9] For spin-½ quark partons, we have $2xF_1(x) = F_2(x)$, the Callan-Gross relation. Thus, in this approximation, R=0 and there is no (1-y) term in the cross section.

• (C.C.) $$\frac{d^2\sigma^{\nu N\to\mu^-X}}{dxdy} = \frac{G^2ME_\ell}{\pi}\,2x\sum_q\left[f_q(x) + f_{\bar q}(x)(1-y)^2\right] .$$

For $\bar\nu N \to \mu^+X$, interchange $f_q(x)$ and $f_{\bar q}(x)$ in the formula. Here $f_q(x)dx$ is the number of quarks q in the target nucleon with momentum fraction x to x+dx. We include $f_q(x)$ and $f_{\bar q}(x)$ in the sum only for negative (positive) charged quarks and antiquarks in $\nu(\bar\nu)$ reactions.

• (N.C.) $$\frac{d^2\sigma^{\nu N\to\nu X}}{dxdy} = \frac{G^2ME_\ell}{\pi}\,2\rho^2x\sum_q\left\{(\epsilon_L^q)^2\left[f_q(x) + f_{\bar q}(x)(1-y)^2\right] + (\epsilon_R^q)^2\left[f_q(x)(1-y)^2 + f_{\bar q}(x)\right]\right\} ,$$

and the sum runs over all quarks. Here the neutral-current coupling is decomposed according to

$$\Gamma_\alpha^q = \epsilon_L^q\,\gamma_\alpha\,\frac{(1-\gamma_5)}{2} + \epsilon_R^q\,\gamma_\alpha\,\frac{(1+\gamma_5)}{2}$$

with left- and right-handed coupling constants ϵ_L^q and ϵ_R^q. In the "standard" SU(2) ⊗ U(1) model

$$\epsilon_L^q = T_3^q - Q_q\sin^2\theta_W \quad , \quad \epsilon_R^q = -Q_q\sin^2\theta_W \quad .$$

For $\bar\nu N \to \bar\nu X$, interchange ϵ_L^q and ϵ_R^q in the cross-section formula.

• (E.M.) $$\frac{d^2\sigma^{e,\mu}}{dxdy} = \frac{8\pi\alpha^2ME_\ell}{(Q^2)^2}\,x\sum_q Q_q^2\left[f_q(x) + f_{\bar q}(x)\right]\frac{1+(1-y)^2}{2} .$$

Comparison with earlier structure function formulas gives:

(C.C.) $$F_2(x) = 2x\sum_q\left[f_q(x) + f_{\bar q}(x)\right],$$

$$xF_3(x) = 2x\sum_q\left[f_q(x) - f_{\bar q}(x)\right];$$

(N.C.) $$F_2(x) = 2\rho^2x\sum_q\left[(\epsilon_L^q)^2 + (\epsilon_R^q)^2\right]\left[f_q(x)+f_{\bar q}(x)\right] ,$$

$$xF_3(x) = 2\rho^2x\sum_q\left[(\epsilon_L^q)^2 - (\epsilon_R^q)^2\right]\left[f_q(x)-f_{\bar q}(x)\right] ,$$

$$F_i^\nu(x) = F_i^{\bar\nu}(x) \quad ;$$

(E.M.) $$F_2(x) = x\sum_q Q_q^2\left[f_q(x) + f_{\bar q}(x)\right] .$$

In the examples below, u(x), $\bar u(x)$, d(x), $\bar d(x)$, etc., mean f_q ($f_{\bar q}$) for the individual quark (antiquark) in the proton (for neutron, interchange u(x) and d(x)). Charm production is taken into account.

• $$F_2^{\nu p\to\mu^-X} = 2x[d(x) + s(x) + \bar u(x) + \bar c(x)] ,$$

$$F_2^{\bar\nu p\to\mu^+X} = 2x[u(x) + c(x) + \bar d(x) + \bar s(x)] ,$$

$$xF_3^{\nu p\to\mu^-X} = 2x[d(x) + s(x) - \bar u(x) - \bar c(x)] ,$$

$$xF_3^{\bar\nu p\to\mu^+X} = 2x[u(x) + c(x) - \bar d(x) - \bar s(x)] .$$

Hereafter we neglect small contributions of the s, $\bar s$, c, $\bar c$ quarks in the sea.

• For charge-symmetric nuclei with $q(x) = u(x) + d(x)$, $\bar q(x) = \bar u(x) + \bar d(x)$,

$$F_2^{\nu N\to\mu^-X} = F_2^{\bar\nu N\to\mu^+X} = x[q(x) + \bar q(x)] ,$$

$$xF_3^{\nu N\to\mu^-X} = xF_3^{\bar\nu N\to\mu^+X} = x[q(x) - \bar q(x)] .$$

• $$F_2^{ep,\mu p}(x) = x\left[\frac{4}{9}\left(u(x) + \bar u(x)\right) + \frac{1}{9}\left(d(x) + \bar d(x)\right)\right]$$

$$F_2^{ed}(x) \cong \frac{5}{18}\,F_{2\ C.C.}^{\nu(\bar\nu)d}$$

$\left(\frac{5}{18}\right.$: average squared charge of u,d quarks$\left.\right)$.

1. S. Weinberg, Phys. Rev. Lett. 19, 1264 (1967); A. Salam, in Elementary Particle Theory, edited by N. Svartholm (Almqvist & Wiksell, Stockholm, 1968), p.367; S. L. Glashow, J. Iliopoulos, and L. Maiani, Phys. Rev. D2, 1285 (1970).
2. M. Kobayashi and K. Maskawa, Prog. Theor. Phys. 49. 652 (1973).
3. R. E. Shrock and L.-L. Wang, Phys. Rev. Lett. 41, 1692 (1978).
4. R. E. Shrock, S. B. Treiman, and L.-L. Wang, Phys. Rev. Lett. 42, 1589 (1979).
5. This determination has been done by, e.g., V. Barger, W. F. Long, and S. Pakvasa, Phys. Rev. Lett. 42, 1585 (1979) and Ref. 4.
6. M. P. Balandin et al., Sov. Phys. JETP 40, 811 (1974).
7. P. Langacker, J. E. Kim, M. Levine, H. H. Williams, and D. P. Sidhu, Univ. of Pennsylvania preprint, Report COO-3071-243, to be published in Proc. Neutrino 1979 Conference, Bergen, Norway, June 1979. A similar analysis has been done by I. Liede and M. Roos, Univ. of Helsinki preprint HU-TFT-79-27.
8. J. D. Bjorken, Phys. Rev. 179, 1547 (1969).
9. J. D. Bjorken and E. A. Paschos, Phys. Rev. 185, 1975 (1969).
10. R. P. Feynman, Photon-Hadron Interactions, (W. A. Benjamin, Reading, MA, 1972).
11. E.g., H. Quinn, Proc. Summer Inst. on Particle Physics, SLAC-215 (1978), p.167.

PARTICLE DETECTORS, ABSORBERS, AND RANGES*

A. DETECTOR PARAMETERS

In this section we give various parameters for common detectors. The quoted numbers represent at best an order of magnitude, and are useful only for preliminary design. A more detailed introduction to detectors can be found in "A Consumer's Guide to Particle Detectors," by D. J. Miller, Rutherford Lab Report RL-76-072, July 1976.

A.1 Scintillators: Photon yield $\approx 1\gamma/100$ eV in plastic scintillator[1] and $\approx 1\gamma/25$ eV in NaI.[1,2]

A.2 Čerenkov:[3] Half-angle θ_c of cone aperture in terms of velocity β and index of refraction n:

$$\theta_c = \text{arc cos}\left(\frac{1}{\beta n}\right) \sim \sqrt{2\left(1-\frac{1}{\beta n}\right)} .$$

Threshold velocity: $\beta_t = 1/n;\quad \gamma_t = 1\Big/\sqrt{1-\beta_t^2}$.

Therefore, $\beta_t\gamma_t = 1\Big/\sqrt{2\delta+\delta^2}$, where $\delta = n-1$. Values of δ for various commonly used gases are given as a function of pressure and wavelength in Ref. 4; for values at atmospheric pressure, see the Table of Atomic and Nuclear Properties following.

Number of photons N per cm:

$$N = \frac{\alpha}{c}\int\left(1-\frac{1}{\beta^2 n^2}\right)2\pi\, d\nu = \frac{\alpha}{c}\beta_t^2\int\left(\frac{1}{\beta_t^2\gamma_t^2}-\frac{1}{\beta^2\gamma^2}\right)2\pi\, d\nu$$

$$\approx 500 \sin^2\theta_c/\text{cm} \quad \text{(visible spectrum)} .$$

A.3 Photon Collection: In addition to the photon yield, one should take into account the light collection efficiency ($\lesssim 10\%$ for typical 1-cm-thick scintillator), attenuation length ($\approx$1 to 4 m for typical scintillators[5]), and quantum efficiency of the photomultiplier cathode ($\lesssim 25\%$).

A.4 Bubble, Streamer, Wire Chambers:

Chamber Type	Accuracy (rms)	Resolution Time	Dead Time
Bubble	$\pm$ 75μ	$\approx$ 1 ms	$\approx$1/20 s[a]
Streamer	$\pm$300μ	$\approx$ 2 μs	$\approx$100 ms
Optical spark	$\pm$200μ[b]	$\approx$ 2 μs	$\approx$ 10 ms
Magnetostrictive Spark	$\pm$500μ	$\approx$ 2 μs	$\approx$ 10 ms
Proportional	$\geq\pm$300μ[c,d]	$\approx$50 ns	$\approx$200 ns
Drift	$\pm$50 to 300μ	$\approx$ 2 ns[e]	$\approx$100 ns

[a] Multiple pulsing time.
[b] 60μ for high pressure.
[c] 300μ is for 1 mm pitch.
[d] Delay line cathode readout can give $\pm$150μ parallel to anode wire.
[e] For two chambers.

A.5 Shower Detectors: Typical energy resolutions (FWHM) for incident electron in the 1 GeV range, E in GeV. For a fixed number of radiation lengths, FWHM in the last three detectors would be expected to be proportional to $\sqrt{t}$ for t (= plate thickness) $\geq$ 0.2 radiation lengths.[6]

NaI (20 rad. lengths):[7] $\dfrac{2\%}{E^{1/4}}$

Lead Glass (14 rad. lengths):[8] $\dfrac{10-12\%}{\sqrt{E}}$

Lead-Liquid Argon (15.75 rad. lengths):[6] $\dfrac{16\%}{\sqrt{E}}$
(42 cells: lead, 2 mm liquid argon, lead-G10, 2 mm liquid argon)

Lead-Scintillator Sandwich (14 rad. lengths):[9] $\dfrac{22\%}{\sqrt{E}}$
(35 cells: 2 mm lead, 12.7 mm scintillator)

Proportional Wire Shower Chamber (17 rad. lengths):[10] $\dfrac{40\%}{\sqrt{E}}$
(36 cells: 0.474 rad. length type-metal + Al, 9.5 mm 80% Ar - 20% CH_4 gas)

A.6 Proportional Chamber Wire Instability: The limit on the voltage V for a wire tension T, due to mechanical effects when the electrostatic repulsion of adjacent wires exceeds the restoring force of wire tension, is given by[11]

$$V \leqslant \frac{sT^{1/2}}{\ell C}$$

where s, ℓ, and C are the wire spacing, length, and capacitance per unit length. An approximation to C for chamber half-gap t and wire diameter d (good for $s \lesssim t$) gives[12]

$$V \lesssim 59T^{1/2}\left[\frac{t}{\ell}+\frac{s}{\pi\ell}\ln\left(\frac{s}{\pi d}\right)\right] ,$$

where V is in kV, and T is in grams.

A.7 Proportional and Drift Chamber Potentials: Potential distributions and fields for an array of parallel line charges q (coul./m) along z and located at $y=0$, $x = 0, \pm a, \pm 2a, \ldots$, can usually be calculated with good accuracy from (MKSA):

$$V(x,y) = -\frac{q}{4\pi\varepsilon_0}\ln\left\{4\left[\sin^2\left(\frac{\pi x}{a}\right)+\sinh^2\left(\frac{\pi y}{a}\right)\right]\right\} .$$

B. COSMIC RAY FLUXES

The fluxes of particles of different types depend on the latitude, their energy, and the conditions of measurement. Some typical sea-level values[13] are given below:

I_v flux per unit solid angle about vertical direction crossing unit horizontal area

J_1 perpendicular component of total flux crossing unit horizontal area from above

J_2 total flux crossing unit horizontal area

	Total Intensity	Hard Component	Soft Component
I_v	1.1×10^{-2}	0.8×10^{-2}	0.3×10^{-2} cm^{-2} sec^{-1} sterad^{-1}
J_1	1.8×10^{-2}	1.3×10^{-2}	0.5×10^{-2} cm^{-2} sec^{-1}
J_2	2.4×10^{-2}	1.7×10^{-2}	0.7×10^{-2} cm^{-2} sec^{-1}

Very approximately, about 75% of all particles at sea-level are penetrating, and are muons. The absolute flux of protons at sea-level, in a momentum range 700-1100 MeV/c, is 1.5×10^{-5} cm^{-2} sec^{-1} sterad^{-1}, or ~0.1% of all particles.

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

C. PASSAGE OF PARTICLES THROUGH MATTER

C.1 Energy Loss Rates for Heavy Charged Projectiles: A heavy projectile (much more massive than an electron) of charge $Z_{inc}e$, incident at speed βc (β >> 1/137) through a slowing medium, dissipates energy principally via interactions with the electrons of the medium. The mean rate of such energy loss per unit path length x may be written as:[14]

$$\left(\frac{dE}{dx}\right)_{inc} = \frac{D\,\rho_{med}\,Z_{med}}{A_{med}}\left(\frac{Z_{inc}}{\beta}\right)^2 \times\left[\ell n\left(\frac{2m_e\gamma^2\beta^2c^2}{I}\right)-\beta^2-\frac{\delta}{2}-\frac{C}{Z_{med}}\right]\{1+\nu\},$$

where $D = 4\pi N_A r_e^2 m_e c^2 = 0.3070$ MeV cm^2/g (see Physical and Numerical Constants Table).

Here Z_{med} and A_{med} are the charge and mass numbers of the medium and ρ_{med} is the mass density of the medium; I, δ, C, and ν are phenomenological functions. Frequently, the values of δ, C, and ν are negligibly small; the parameter I characterizes the binding of the electrons of the medium. As a rule of thumb, we may estimate I for an idealized medium as $I \simeq 16\,(Z_{med})^{0.9}$ eV when $Z_{med} > 1$. For realistic media the value of I will vary at the 10% level from this estimate; for H_2, I = 20.0 eV. We may approximately treat media which are chemical mixtures or compounds by computing

$$\frac{dE}{dx} \approx \sum_{n=1}^{N}\left(\frac{dE}{dx}\right)_n ,$$

with $(dE/dx)_n$ appropriate to the n^{th} chemical constituent (using $\rho^{(n)}_{med}$ as the partial density).[15]

The function δ represents the density effect upon the energy loss rate; it is non-negligible only for highly relativistic projectiles in dense media.[16] For ultra-relativistic projectiles, δ approaches $2\ell n\gamma$ + constant, where the value of the constant depends upon the density of the medium and its chemical composition.

The function C represents shell corrections to the energy loss rate.[14] These effects are non-negligible only for projectiles with speeds not much faster than the speeds of the fastest electrons bound in the medium.

The function ν represents corrections due to higher-order electrodynamics.[17] These effects become important when $|Z_{inc}/\beta|$ is comparable to 137. For relativistic unit-charge projectiles, $|\nu|$ is of the order of 1%; positively charged projectiles lose energy more rapidly than do their charge conjugates.[17,18]

$(dE/dx)_{inc}$ falls rapidly with β until reaching a minimum around β = 0.96 (almost independent of medium), followed by a slow rise. Because of the density effect, the quantity in square brackets approaches $\ell n\gamma$ + constant for large γ.

The value $(dE/dx)_{inc}\delta x$ is the mean total energy loss via interactions with electrons of the medium in a layer of thickness δx. For any finite δx, Poisson fluctuations can cause the actual energy loss to deviate from the mean. For thin layers, the distribution is broad and skewed, being peaked below $(dE/dx)\delta x$, and having a long tail toward large energy losses.[19] Only for a very thick layer $[(dE/dx)\delta x >> 2m_e\beta^2\gamma^2c^2]$ will the distribution of energy losses become nearly Gaussian. The large fluctuations of the total energy loss rate from the mean are due to a small number of collisions with large energy transfers. The fluctuations are greatly reduced for the so-called restricted energy loss rate, described in section C.3.

C.2 Energetic Knock-On Electrons: For a spinless point-charge projectile, the production of high energy (kinetic energy T >> I) electrons is given by (neglecting the spin of the electron):

$$\frac{dN}{dTdx} = \tfrac{1}{2}D\left(\frac{Z_{med}}{A_{med}}\right)\left(\frac{Z_{inc}}{\beta}\right)^2\rho_{med}\frac{1}{T^2} ,$$

$$\text{for}\quad I \ll T \leq T_{max};\quad T_{max} = \frac{2m_e\beta^2\gamma^2c^2}{1+2\gamma\frac{m_e}{M_{inc}}+\left(\frac{m_e}{M_{inc}}\right)^2} ,$$

where M_{inc} is the mass of the incident projectile and all other quantities are as in section C.1. This formula does not differ significantly from the precise result, incorporating spin effects, for any projectile (including $e^\pm$) in the restricted range $I << T << T_{max}$; more accurate formulae are available for various projectiles.[20,21] Our formula is inaccurate for T close to I; for $2I \lesssim T \lesssim 10I$, the $1/T^2$ dependence above becomes $\simeq T^{-\eta}$ with $3 \lesssim \eta \lesssim 5$.[22]

C.3 Rates of Restricted Energy Loss for Charged Projectiles: The variability of energy loss for heavy projectiles is due primarily to the variability in the production of energetic knock-on electrons. Bremsstrahlung and pair production processes make this variability even greater for electrons than for heavy particles as projectiles (see, e.g., the figure "Fractional Energy Loss for e^+ and e^- in Lead"). If an instrument is capable of isolating these high-energy-loss interactions, then it is appropriate to consider the rate of energy loss excluding them, i.e., a restricted energy loss rate. The mean energy loss rate via all collisions which have energy transfer T such that $T \leq E_{max} \ll T_{max}$ is:[14]

$$\left(\frac{dE}{dx}\right)_{\leq E_{max}} = \frac{D}{2}\,\frac{Z_{med}\,\rho_{med}}{A_{med}}\left(\frac{Z_{inc}}{\beta}\right)^2 \times\left[\ell n\left(\frac{E_{max}\,T_{max}}{I^2}\right)-\beta^2-\delta-\frac{2C}{Z_{med}}\right]$$

Notice the overall factor of 1/2.

The density effect causes the restricted energy loss rate to approach a constant, the Fermi plateau value, for the fastest projectiles.

C.4 Multiple Coulomb Scattering through Small Angles: As a charged particle traverses a medium it is deflected via many independent small-angle Coulomb scatterings. The bulk of this deflection is due to scattering from the nuclei in the medium. The non-projected (space) and projected (plane) distributions are given approximately[23] by the Gaussian forms:

$$f(\theta_{space})d\Omega \cong \frac{1}{\pi\theta_0^2}\exp\left(-\frac{\theta^2_{space}}{\theta_0^2}\right)d\Omega ,$$

$$g(\theta_{plane})d\theta_{plane} \cong \frac{1}{\sqrt{\pi}\theta_0}\exp\left(-\frac{\theta^2_{plane}}{\theta_0^2}\right)d\theta_{plane} ,$$

where

$$\theta_0 = \frac{20\ \text{MeV}/c}{p\beta}\,Z_{inc}\sqrt{\frac{L}{L_R}}\left[1+\frac{1}{9}\log_{10}\left(\frac{L}{L_R}\right)\right]\ \text{(radians)},$$

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

p, β, and Z_{inc} are the momentum (in MeV/c), velocity, and charge number of the incident particle, and L/L_R is the thickness, in radiation lengths, of the scattering medium. L_R for certain materials is given in the Table of Atomic and Nuclear Properties of Materials. The 1/e angle, θ_0, is a fit to Moliere[24] theory accurate to about 5% for $10^{-3} < L/L_R < 10$ except for very light elements or low velocity where the error is about 10 to 20%. In this Gaussian approximation, θ_0 has the meaning

$$\theta_0 = \theta^{rms}_{space} = \sqrt{2}\,\theta^{rms}_{plane} .$$

Beyond angles of about $2\theta_0$, the true distribution function has a long tail which contributes at the level of roughly 1% of peak height, slowly descending, beyond the point at which the Gaussian would be negligible, to the height expected for single large-angle Rutherford or nuclear scatters.

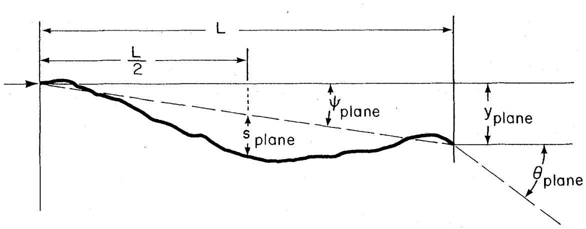
Other quantities are sometimes used to describe the amount of multiple Coulomb scattering: the auxiliary quantities ψ_{plane}, y_{plane}, and s_{plane} (see the figure) obey:

$$\psi^{rms}_{plane} = \frac{1}{\sqrt{3}}\,\theta^{rms}_{plane} ,$$

$$y^{rms}_{plane} = \frac{1}{\sqrt{3}}\,L\,\theta^{rms}_{plane} ,$$

and

$$s^{rms}_{plane} = \frac{1}{4\sqrt{3}}\,L\,\theta^{rms}_{plane} .$$



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All the quantitative estimates in this section apply only in the limit of small θ^{rms}_{plane} and in the absence of large-angle scatters.

C.5 Electron Range in Lead, Copper, Carbon, and Hydrogen: See figure following.

C.6 Fractional Energy Loss for Electrons and Positrons in Lead: See figure following.

C.7 Contributions to Photon Cross Section in Lead: See figure following.

C.8 Photon Mass Attenuation Coefficients, Energy Deposition: See figure following.

D. ATOMIC AND NUCLEAR PROPERTIES OF MATTER

See Table following.

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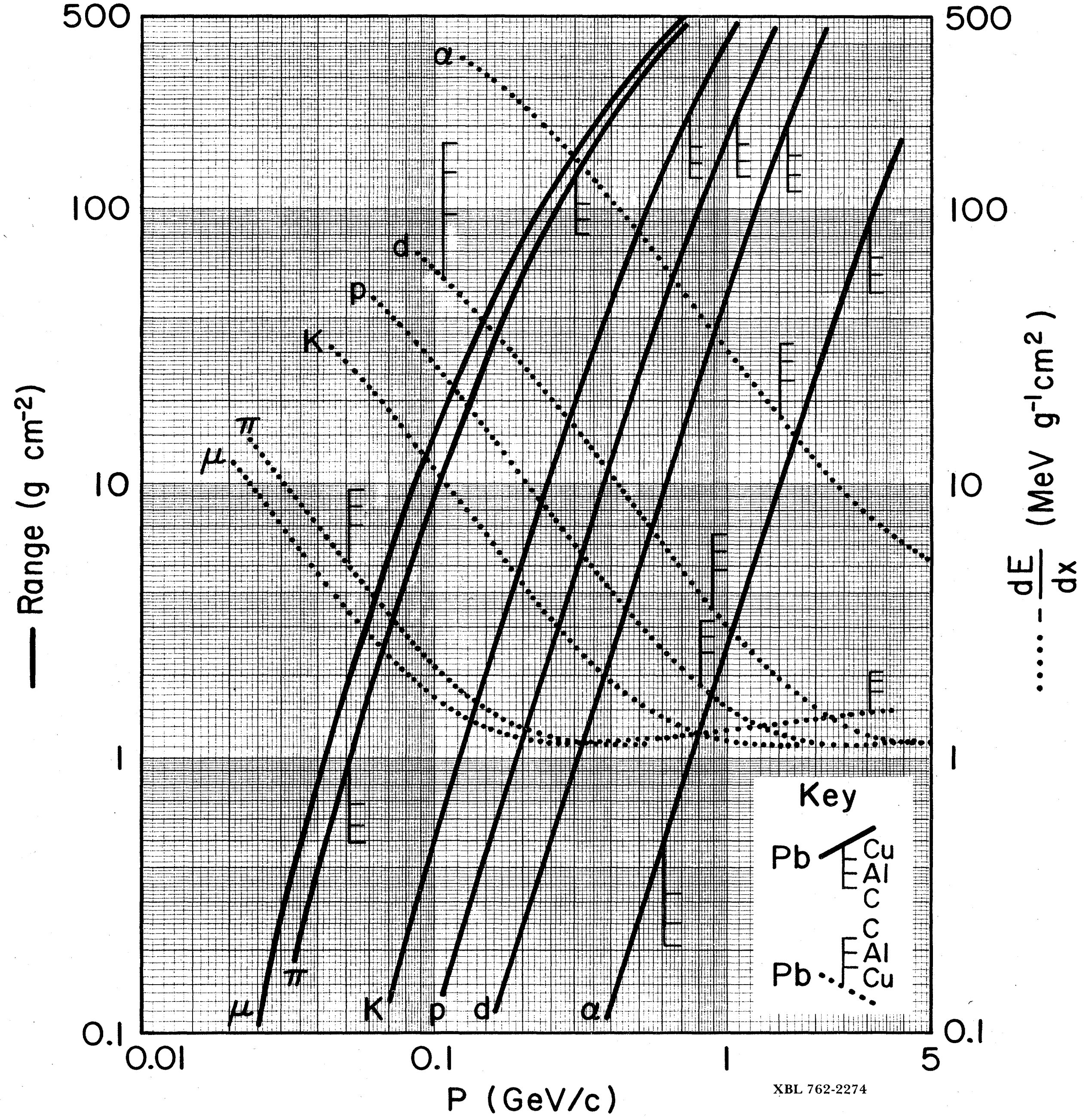
*Prepared April 1974 by Sherwood Parker and Bernard Sadoulet. Revised April 1980 by Sherwood Parker and Ray Hagstrom.

1. Methods of Experimental Physics, L.C.L. Yuan and C.-S. Wu, editors, Academic Press, 1961, Vol. 5A, p.127.
2. R. K. Swank, Ann. Rev. Nuc. Sci. 4, 137 (1954) and G. T. Wright, Proc. Phys. Soc. B68, 929 (1955).
3. Methods of Experimental Physics, L.C.L. Yuan and C.-S. Wu, editors, Academic Press, 1961, Vol. 5A, p.163.
4. E. R. Hayes, R. A. Schlutter, and A. Tamosaitis, "Index and Dispersion of Some Čerenkov Counter Gases," ANL-6916 (1964).
5. Nuclear Enterprises Catalogue.
6. D. Hitlin et al., Nucl. Instr. and Meth. 137, 225 (1976). See also W. J. Willis and V. Radeka, Nucl. Instr. and Meth. 120, 221 (1974), for a more detailed discussion.
7. E. B. Hughes et al., IEEE Transactions on Nuclear Science, NS-19, No. 3,126 (1972).
8. M. Holder et al., Phys. Letters 40B, 141 (1972), and J. S. Beale et al., "A Lead-Glass Čerenkov Detector for Electrons and Photons," CERN Writeup, Intl. Conf. on Instrumentation in H.E.P., Frascati (1973).
9. W. B. Atwood et al., "First Test of a New Shower Detector," SLAC-TN-76-7 (1976). See also J. K. Walker and T. R. Knasel, Rev. Sci. Instr. 37, 913 (1966).
10. R. L. Anderson et al., "Tests of Proportional Wire Shower Counter and Hadron Calorimeter Modules," SLAC-PUB-2039 (1977).
11. T. Trippe, CERN NP Internal Report 69-18 (1969).
12. S. Parker and R. Jones, LBL-797 (1972), and A. Morse and B. Feshbach, Methods of Theoretical Physics, McGraw-Hill, New York, 1953, p.1236.
13. B. Rossi, Rev. Mod. Phys. 20, 537 (1948).
14. U. Fano, Ann. Rev. Nucl. Sci. 13, 1 (1963).
15. H. A. Bethe and J. Ashkin, Experimental Nuclear Physics, Vol. 1, E. Segrè, editor, John Wiley, New York, 1959.
16. A. Crispin and G. N. Fowler, Rev. Mod. Phys. 42, 290 (1970).
17. For Z^3 calculations with $Z = 1$, see J. D. Jackson and R. L. McCarthy, Phys. Rev. B6, 4131 (1972).
18. For an approximate treatment of high-Z projectiles, see P. B. Eby and S. H. Morgan, Phys. Rev. A5, 2536 (1972).
19. See, for instance, K. A. Ispirian, A. T. Margarian, and A. M. Zverev, Nucl. Instr. and Meth. 117, 125 (1974).
20. For unit-charge projectiles, see E. A. Uehling, Ann. Rev. Nucl. Sci. 4, 315 (1954).
21. For highly charged projectiles, see J. A. Doggett and L. V. Spencer, Phys. Rev. 103, 1597 (1956). A Lorentz transformation is needed to convert these center-of-mass data to knock-on energy spectra.
22. N. F. Mott and H. S. W. Massey, The Theory of Atomic Collisions, Oxford Press, London, 1965.
23. J.D.Jackson, Classical Electrodynamics, John Wiley & Sons, New York, 1975. V.L. Highland, Nucl. Instr. & Meth. 129, 497 (1975); 161, 171 (1979); and earlier references therein. G. Shen, et al., Phys. Rev. D20, 1584 (1979). Their data, taken at high energies, agrees with Moliere theory. They find the Highland formula for θ_0 to be 11% high for hydrogen and 1 to 5% high for higher-Z targets.
24. G.Moliere, Z. Naturforsch 2a, 133 (1947) and 3a, 78 (1948). H.A.Bethe, Phys. Rev. 89, 1256 (1953).

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

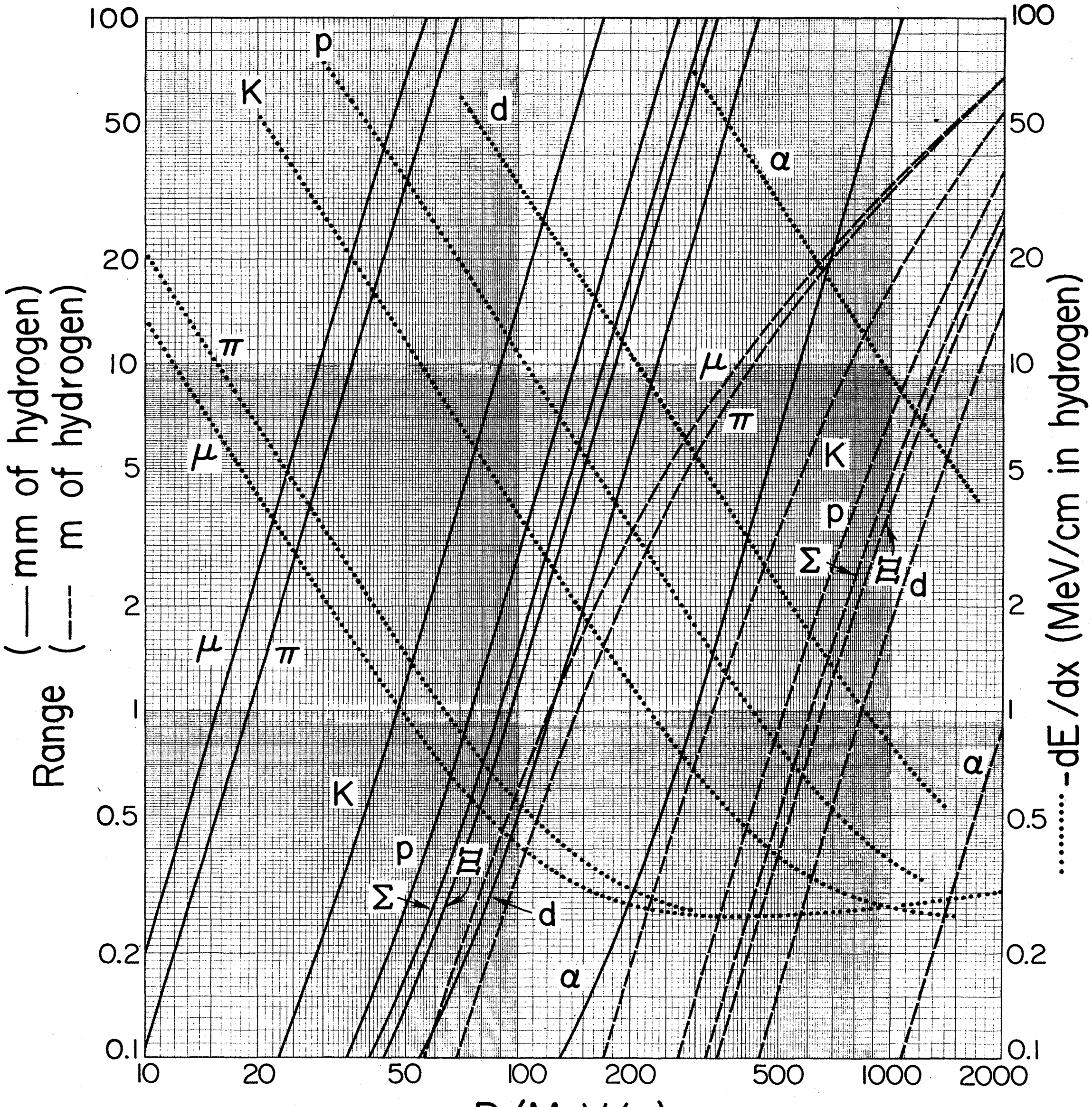
Mean Range and Energy Loss in Lead, Copper, Aluminum, and Carbon



Mean range and energy loss due to ionization for the indicated particles in Pb, with scaling to Cu, Al, and C indicated, using Bethe-Bloch equation (Section C.1 above) with corrections. Calculated using program of Hans Bichsel (UCRL-17538), with density correction added (Hans Bichsel, private communication). See also Joseph F. Janni [Air Force Weapons Laboratory Technical Report No. AFWL-TR-65-150 (1966)]. The average ionization potentials (I) assumed were: Pb (820 eV), Cu (320 eV), Al (166 eV), and C(77.5 eV). Figure indicates total path length; observed range may be smaller (by ~ 1% - 2% in heavy elements) due to multiple scattering, primarily from small energy-loss collisions with nuclei. The functional forms have not been experimentally verified to better than roughly ±1%. For higher energies refer to discussion by Cobb ["A Study of Some Electromagnetic Interactions of High Velocity Particles with Matter," University of Oxford Report HEP/T/55 (1973)] and by Turner ["Penetration of Charged Particles in Matter: A Symposium", National Academy of Sciences, Washington D.C. (1970), p. 48]. Scaling to other beam particles is, to a good approximation, described by the expression on the next page.

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Mean Range and Energy Loss in Liquid Hydrogen



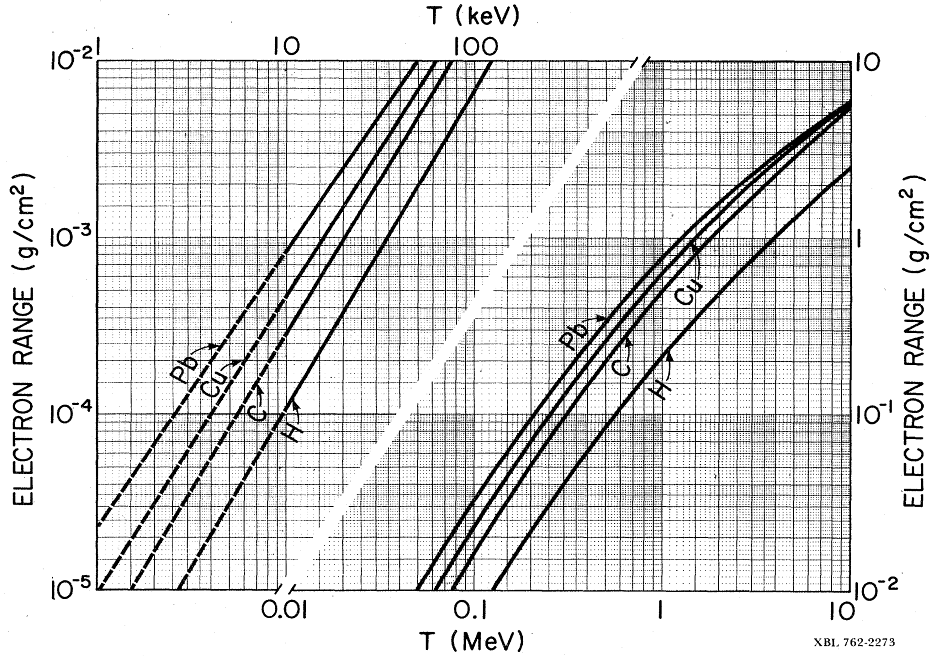
XBL 761-2150

Range and energy loss in liquid hydrogen bubble chamber, based on Bethe-Bloch equation (Section C.1 above), using an average ionization potential for H_2 of I = 20.0 eV, which is an approximate average of the experimental result of Garbincius and Hyman [Phys. Rev. A2, 1834 (1970)] and the theoretical result of Ford and Browne [Phys. Rev. A7, 418 (1973)]. Bubble chamber conditions are chosen to be those of Garbincius and Hyman: parahydrogen of density = 0.0625 g/cm^3 (note: range ∝ 1/density), with vapor-pressure 60.8 lb/in^2 (absolute) and temperature 26.2°K. The functional dependence of the Bethe-Bloch equation is not experimentally verified to better than about ±1% over large momentum ranges. It should be noted that the number of bubbles per cm of a track in a bubble chamber is nearly proportional to $1/\beta^2$, not dE/dx. For the linear portions of the range curves, $R \propto p^{3.6}$. Scaling law for particles of other mass or charge (except electrons): for a given medium, the range R_b of any beam particle with mass M_b, charge z_b, and momentum p_b is given in terms of the range R_a of any other particle with mass M_a, charge z_a, and momentum $p_a = p_b M_a/M_b$ (i.e., having the same velocity) by the expression:

$$R_b(M_b, z_b, p_b) = \left[\frac{M_b/M_a}{z_b^2/z_a^2}\right] R_a(M_a, z_a, p_a = p_b M_a/M_b) \ .$$

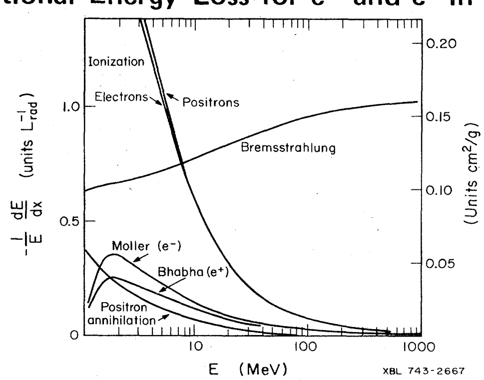
PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Mean Electron Range in Lead, Copper, Carbon, and Liquid Hydrogen



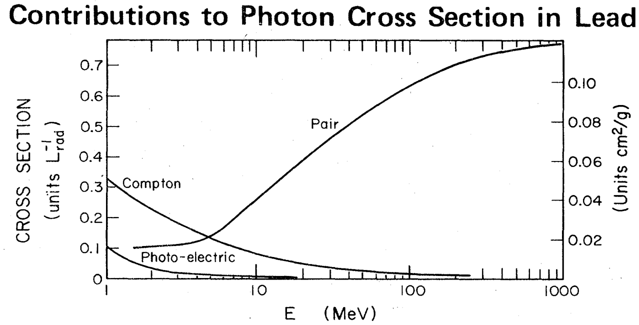
Mean range of electrons in the continuous-slowing-down approximation, taking into account energy loss by collisions with atomic electrons and by bremsstrahlung; strong fluctuations are to be expected for individual tracks. This range is the total path length; the "practical range" — a common measure of straight-line penetration distance — is shorter because of multiple Coulomb scattering, which becomes increasingly important as the electron slows down. E.g., for a fast electron the rms projected angle due to multiple Coulomb scattering reaches 1 radian by the time the electron has slowed to 0.4 MeV in hydrogen, 1.5 MeV in carbon, 9 MeV in copper, and 24 MeV (off scale) in lead. Electron energy deposition and penetration probability vs. range are discussed by L. V. Spencer, "Energy Dissipation by Fast Electrons," NBS Monograph #1, 1959, and S. M. Seltzer, "Transmission of Electrons through Foils," NBSIR 74, 457 (1974). Electrons which have energy less than 0.2 MeV in Ar, 1.5 MeV in Cu, 3.5 MeV in Sn, and 5 MeV in Pb are likely to deposit 10% of their energy behind their starting plane. The practical range, R_p, is defined as that absorber thickness obtained by extrapolating to zero the linearly decreasing part of the curve of penetration probability vs. absorber thickness. Data for Al in the T range of the figure are available, and fit (to ~±10%) $R_p = AT[1-B/(1+CT)]$ mg cm^{-2} [a form suggested by K.-H. Weber, Nucl. Inst. Meth. 25, 261 (1964)], with A=0.55 mg cm^{-2} keV^{-1}, B = 0.9841, and C = 0.0030 keV^{-1}. At this penetration depth, 90 - 95% of the incident electrons have stopped. Data for other elements are sketchy, but suggest that higher-Z ($\lesssim$50) elements have $1 \lesssim R_p/R_p(\mathrm{Al}) \lesssim 1.4$ below ~10 keV, and $0.6 \lesssim R_p/R_p(\mathrm{Al}) \lesssim 1$ above ~100 keV. The "critical energy" (above which the energy loss due to bremsstrahlung exceeds that due to ionization, and showering becomes important) is 400 MeV for hydrogen, 100 MeV for carbon, 25 MeV for copper, and 10 MeV for lead. The mean positron range may differ from the mean electron range by several percent. See Berger and Seltzer, NASA SP-3012 (1964) and SP-3036, and P. Trower, UCRL-2426, Vol. III, Rev. (1966). 1 - 10 keV range was obtained by linear extrapolation; in this region the true range may actually lie above the curves.

Fractional Energy Loss for e^+ and e^- in Lead



Fractional energy loss per radiation length in lead as a function of electron or positron energy. Electron (positron) scattering is considered as ionization when the energy loss per collision is below 0.255 MeV, and as Moller (Bhabha) scattering when it is above.

Contributions to Photon Cross Section in Lead

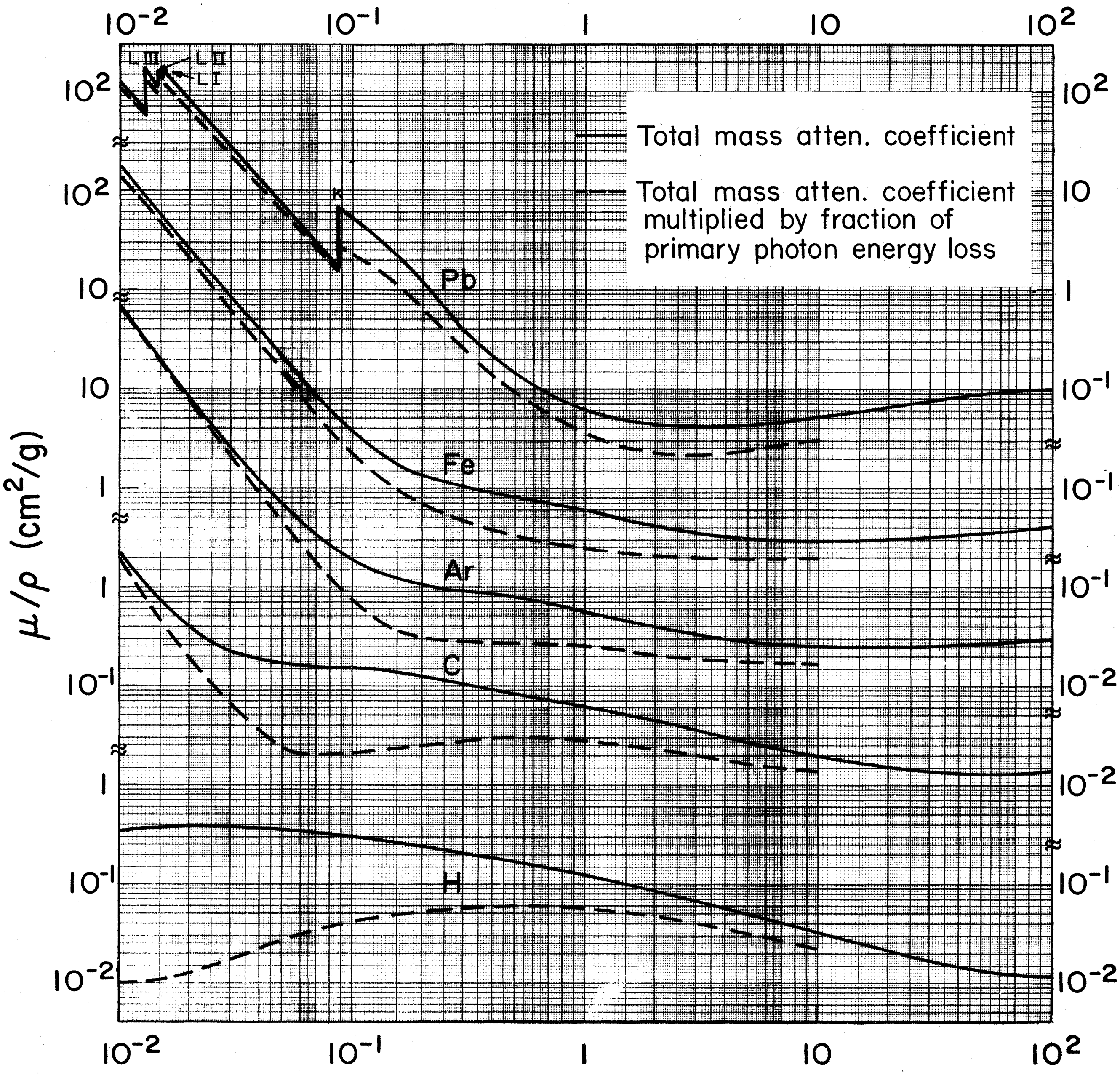


Photon cross section in lead in inverse radiation lengths as a function of photon energy. The intensity of photons can be expressed as $I = I_0 \exp(-\sigma x)$, where σ is read above and x is the path length in radiation lengths. See also figure following.

These figures are adapted from Fig. 3.2 and Fig. 3.3 from Messel and Crawford, Electron-Photon Shower Distribution Function Tables for Lead, Copper and Air Absorbers, Pergamon Press, 1970. Messel and Crawford use L_r (Pb) = 5.82 g/cm^2, but we have modified the figures to reflect the value given in the Table of Atomic and Nuclear Properties of Materials (following), namely L_r(Pb) = 6.4 g/cm^2. The development of electron-photon cascades is approximately independent of absorber when the results are expressed in terms of inverse radiation lengths (i.e., scales on left of plots).

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Photon Mass Attenuation Coefficients, Energy Deposition



The photon mass attenuation coefficient for various absorbers as a function of photon energy (solid curves). For a homogeneous medium of density ρ, the intensity I remaining after traversal of thickness t is given by $I = I_o \exp(-\mu t)$. The accuracy is a few percent. Interpolation to other Z should be done in the cross section $\sigma = (\mu/\rho)\ M/N_A\ cm^2/atom$, where M is the atomic weight of the absorber material and N_A is Avogadro's number. For a chemical compound or mixture, use $(\mu/\rho)_{eff} \cong \sum_i w_i(\mu/\rho)_i$, accurate to a few percent, where w_i is the proportion by weight of the i^{th} constituent. The dashed curve is the mass energy-absorption coefficient, giving μ/ρ multiplied by the fraction of photon energy deposited in a small volume (assumed large enough to contain the ranges of most secondary electrons) about the interaction. This fraction is smaller than 1.0 because such processes as Compton scattering and electron bremsstrahlung imply radiation of some of the energy away from the immediate area. From J. H. Hubbell, NSRDS-NBS 29(1969).

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Atomic and Nuclear Properties of Materials*

Material	Z	A	Nuclear cross section σ[a] [barns]	Nuclear collision length $L_{coll.}$[b] [g/cm²]	[cm]	Absorption length λ[b] [cm]	dE/dx min[c] [MeV/g/cm²]	[MeV/cm]	Radiation length L_{rad}[d] [g/cm²]	[cm]	Density[e] [g/cm³] () is for gas [g/ℓ]	Refractive index n;[e] () is $(n-1)\times10^6$ for gas
H_2	1	1.01	0.039	43.0	607	790	4.12	0.292	63.05	890	0.0708 (0.090)	1.112 (140)
D_2	1	2.01	0.074	45.1	273	342	2.07	0.342	126.1	764	0.163	1.128
He	2	4.00	0.134	49.6	397	478	1.94	0.243	94.32	755	0.125 (0.178)	1.024 (35)
Li	3	6.94	0.215	53.6	100.4	120.6	1.65	0.881	82.76	155	0.534	-
Be	4	9.01	0.270	55.4	30.0	36.7	1.61	2.97	65.19	35.3	1.848	-
C	6	12.01	0.340	58.7	≈37.8	49.9	1.78	≈2.76	42.70	≈27.5	≈1.55[f]	-
N_2	7	14.01	0.390	59.7	73.8	99.4	1.82	1.47	37.99	47.0	0.808 (1.25)	1.205 (300)
Ne	10	20.18	0.520	64.4	53.7	74.9	1.73	2.08	28.94	24.0	1.207 (0.90)	1.092 (67)
Al	13	26.98	0.650	68.9	25.5	37.2	1.62	4.37	24.01	8.9	2.70	-
Ar	18	39.95	0.890	74.5	53.2	80.9	1.51	2.11	19.55	14.0	1.40 (1.78)	1.233 (283)
Fe	26	55.85	1.160	79.9	10.2	17.1	1.48	11.6	13.84	1.76	7.87	-
Cu	29	63.54	1.270	83.1	9.3	14.8	1.44	12.9	12.86	1.43	8.96	-
Sn	50	118.69	2.040	96.6	13.2	22.8	1.28	9.4	8.82	1.21	7.31	-
W	74	183.85	2.810	108.6	5.6	10.3	1.17	22.6	6.76	0.35	19.3	-
Pb	82	207.19	3.080	111.7	9.8	18.5	1.13	12.8	6.37	0.56	11.35	-
U	92	238.03	3.380	116.9	≈6.2	12.0	1.09	≈20.7	6.00	≈0.32	≈18.95	-
Air				60.2	50000[g]	67500[g]	1.82	0.0022[g]	36.20	30050[g]	0.001205[g] (1.29)	1.000273[g] (293)
H_2O				58.3	58.3	78.8	2.03	2.03	36.08	36.1	1.00	1.33
H_2 (bubble chamber 26°K)[h]				43.0	≈683	887	4.12	≈0.26	63.05	≈1000	≈0.063[h]	1.112
D_2 (bubble chamber 31°K)[h]				45.1	≈322	403	2.07	≈0.29	126.1	≈900	≈0.140[h]	1.110
H-Ne mixture (50 mole percent)[i]				62.9	154.5	215	1.84	0.75	29.70	73.0	0.407	1.092
Propane (C_3H_8)[j]				55.0	134	176	2.28	0.98	45.38	111	0.41[j] (2.0)	1.25[j] (1005)
Freon 13B1 (CF_3Br)[j]				74.3	≈49.5	73.5	1.52	≈2.3	16.53	≈11	≈1.50[j] (8.71)	1.238[j] (750)
Ilford emulsion				88.1	23.1	36.7	1.44	5.49	11.02	2.94	3.815	-
NaI				91.9	25.0	41.3	1.32	4.84	9.49	2.59	3.67	1.775
LiF				61.1	23.1	30.7	1.69	4.46	39.25	14.9	2.64	1.394
Polyethylene (CH_2)				55.7	≈59.6	78.4	2.09	≈1.95	44.78	≈48	0.92–0.95	-
Mylar ($C_5H_4O_2$)				58.5	42.1	56.1	1.91	2.65	39.95	28.7	1.39	-
Polystyrene, scintillator (CH)[k]				57.0	55.2	68.5	1.97	2.03	43.8	42.9	1.032	1.581
Lucite, Plexiglas ($C_5H_8O_2$)				57.7	≈48.9	65.0	1.97	≈2.32	40.55	≈34.5	1.16–1.20	≈1.49
Spark or proportional chamber[ℓ]				0.030%		0.022%	-	0.034	0.067%		0.019	-
Shielding concrete[m]				65.5	26.2	36.8	1.70	4.25	26.7	10.7	2.5	-
CO_2[n]				60.4	33800	46000	1.82	0.0033	36.2	20210	(1.79)[n]	(410)[n]
Freon 12 (CCl_2F_2)[n]				68.1	13800	20200	1.64	0.0081	23.7	4810	(4.93)[n]	(1080)[n]
Freon 13 ($CClF_3$)[n]				66.0	15000	21400	1.70	0.0072	27.15	6380	(4.26)[n]	(720)[n]
Silica Aerogel[o]				62.3	≈311	430	1.82	≈0.36	30	≈150	0.1–0.3	1.0+0.25ρ

*) Table revised April 1980 by J. Engler and F. Mönnig. For details, see CERN NP Internal Report 74-1.

a) σ of neutrons (≈ σ of protons) at 20 GeV from Landolt-Bornstein, New Series I, Vol. 5. Energy dependence for all nuclei ≈ 1/2 percent/GeV (from 5–25 GeV).

b) $L_{coll} = A/(N.\sigma)$. In the absorption length the elastic scattering is subtracted.

c) For a minimum-ionizing, singly-charged particle in the material. From W.H. Barkas and M.J. Berger, Tables of Energy Losses and Ranges of Heavy Charged Particles, NASA-SP-3013 (1964).

d) From Y.S. Tsai, Rev. Mod. Phys. **46**, 815 (1974).

e) Values for solids, or the liquid phase at boiling point, except where noted. Values in parentheses for gaseous phase STP (0°C, 1 atm.), except where noted.

f) Density variable.

g) Gas at 20°C.

h) Density may vary about ±3%, depending on operating conditions.

i) Values for typical working condition with H_2 target: 50 mole percent, 29°K, 7 atm.

j) Values for typical chamber working conditions: Propane ~ 57°C, 8–10 atm. Freon 13B1 ~ 28°C, 8–10 atm.

k) Typical scintillator; e.g. PILOT B and NE 102A have an atomic ratio H/C = 1.10.

ℓ) Values for typical construction: 2 layers 50 μm Cu/Be wires, 8 mm gap, 60% argon, 40% isobutane or CO_2; 2 layers 50 μm Mylar/Aclar foils.

m) Standard shielding blocks, typical composition O_2 52%, Si 32.5%, Ca 6%, Na 1.5%, Fe 2%, Al 4% plus reinforcing iron bars. Attenuation length ℓ = 115 ± 5 g/cm², also valid for earth (typical ρ = 2.15) from CERN-LRL-RHEL Shielding exp. UCRL 17841 (1968).

n) Used in Čerenkov counters, value at 26°C and 1 atm. Indices of refraction from E.R. Hayes, R.A. Schluter, and A. Tamosaitis, ANL-6916 (1964).

o) $n(SiO_2) + 2n(H_2O)$ used in Čerenkov counters, ρ = density in g/cm³. From M. Cantin et al., Nucl. Instr. Meth. **118**, 177 (1974).

ELECTROMAGNETIC RELATIONS

Maxwell's Equations

Quantity	CGS (statcoul., statamp., sec cm^{-1})	MKSA (coul., amp., ohm)
Potentials:	$V = \sum_{\text{charges}} \frac{q}{r}$	$V = \frac{1}{4\pi\epsilon_0} \sum_{\text{charges}} \frac{q}{r}$
	$\vec{A} = \frac{1}{c} \sum_{\text{currents}} \frac{\vec{I}}{r}$	$\vec{A} = \frac{\mu_0}{4\pi} \sum_{\text{currents}} \frac{\vec{I}}{r}$
	c = speed of light in vacuum	$\epsilon_0 = \frac{1}{36\pi} 10^{-9}$ MKSA
		$\mu_0 = 4\pi\, 10^{-7}$ MKSA
Fields:	$\vec{E} = -\vec{\nabla}V - \frac{1}{c}\frac{\partial\vec{A}}{\partial t}$	$\vec{E} = -\vec{\nabla}V - \frac{\partial\vec{A}}{\partial t}$
	$\vec{B} = \vec{\nabla}\times\vec{A}$	$\vec{B} = \vec{\nabla}\times\vec{A}$
Materials:	$\vec{D} = \epsilon\vec{E}, \quad \vec{B} = \mu\vec{H}$	$\vec{D} = \epsilon\vec{E}, \quad \vec{B} = \mu\vec{H}$
Force:	$\vec{F} = q\left(\vec{E} + \frac{\vec{v}}{c}\times\vec{B}\right)$	$\vec{F} = q(\vec{E} + \vec{v}\times\vec{B})$
Maxwell:	$\vec{\nabla}\cdot\vec{D} = 4\pi\rho$	$\vec{\nabla}\cdot\vec{D} = \rho$
	$\vec{\nabla}\times\vec{E} = -\frac{1}{c}\frac{\partial\vec{B}}{\partial t}$	$\vec{\nabla}\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}$
	$\vec{\nabla}\cdot\vec{B} = 0$	$\vec{\nabla}\cdot\vec{B} = 0$
	$\vec{\nabla}\times\vec{H} = \frac{4\pi\vec{j}}{c} + \frac{1}{c}\frac{\partial\vec{D}}{\partial t}$	$\vec{\nabla}\times\vec{H} = \vec{j} + \frac{\partial\vec{D}}{\partial t}$
Relativistic transformations:	$\vec{E}'_{\parallel} = \vec{E}_{\parallel}$	$\vec{E}'_{\parallel} = \vec{E}_{\parallel}$
	$\vec{E}'_{\perp} = \gamma\left(\vec{E}_{\perp} + \frac{1}{c}\vec{v}\times\vec{B}\right)$	$\vec{E}'_{\perp} = \gamma(\vec{E}_{\perp} + \vec{v}\times\vec{B})$
	$\vec{B}'_{\parallel} = \vec{B}_{\parallel}$	$\vec{B}'_{\parallel} = \vec{B}_{\parallel}$
	$\vec{B}'_{\perp} = \gamma\left(\vec{B}_{\perp} - \frac{1}{c}\vec{v}\times\vec{E}\right)$	$\vec{B}'_{\perp} = \gamma\left(\vec{B}_{\perp} - \frac{1}{c^2}\vec{v}\times\vec{E}\right)$

Impedances: Alternating Currents (MKSA)

Ohm's law: $V = ZI, \quad V = V_0 e^{i\omega t}$.

1. Impedance of self-inductance L: $Z = i\omega L$.
2. Impedance of a capacitor of capacitance C: $Z = \frac{1}{i\omega C}$.
3. Impedance of a flat conductor of width w at high frequency:

$$Z = \frac{(1+i)\rho}{w\delta} ;$$

ρ = resistivity in 10^{-8} Ωm:

~1.7 for Cu	~5.5 for W
~2.4 for Au	~73 for SS 304
~2.8 for Al (Al alloys may have up to double this value.)	~100 for Nichrome

δ = effective skin depth

$$= \sqrt{\frac{\rho}{\pi\nu\mu}} \approx \frac{6.6 \text{ cm}}{\sqrt{\nu(\sec^{-1})}} \quad \text{for Cu} \; .$$

4. Impedance of free space: $Z = \sqrt{\mu_0/\epsilon_0} = 376.7\Omega$.

Capacitance C and Inductance L per Unit Length (MKSA)

1. For flat plates of width w, separated by d << w:

$$C = \frac{\epsilon w}{d} \; ; \qquad L = \mu\frac{d}{w} \; .$$

2. For coax cable of interior and exterior radii r_1 and r_2:

$$C = \frac{2\pi\,\epsilon}{\ell n(r_2/r_1)} \; ; \qquad L = \frac{\mu}{2\pi}\,\ell n(r_2/r_1) \; ;$$

ϵ = dielectric constant {2 to 6 for plastics; 4 to 8 for porcelain, glasses;

μ = magnetic susceptibility.

Transmission Lines (No Loss) (MKSA)

Velocity = $1/\sqrt{LC} = 1/\sqrt{\mu\epsilon}$.

Impedance = $\sqrt{L/C}$.

L and C are inductance and capacitance per unit length.

Synchrotron Radiation (CGS)

Energy loss/revolution = $\frac{4\pi}{3}\frac{e^2}{\rho}\beta^3\gamma^4$, ρ = orbit radius .

For electrons ($\beta \approx 1$), $\frac{\Delta E(\text{MeV})}{\text{rev.}} = 0.0885\,[E(\text{GeV})]^4/\rho(\text{meter})$.

Critical frequency: $\omega_c = 3\gamma^3 \frac{c}{\rho}$.

Frequency spectrum (for $\gamma >> 1$):

$$I(\omega) \cong 3.3\,\frac{e^2}{c}\left(\frac{\omega\rho}{c}\right)^{1/3} , \qquad \omega << \omega_c \; ;$$

$$I(\omega) \cong (1.0,\ 1.6,\ 1.6,\ 0.5,\ 0.08)\,\frac{e^2\gamma}{c}$$

at $\frac{\omega}{\omega_c}$ = 0.01, 0.1, 0.2, 1.0, 2.0, respectively;

$$I(\omega) \cong \sqrt{3\pi}\,\frac{e^2\gamma}{c}\left(\frac{\omega}{\omega_c}\right)^{1/2} e^{-2\omega/\omega_c} , \qquad \omega \gtrsim 2\omega_c \; .$$

The radiation is confined to angles $\lesssim 1/\gamma$ relative to the instantaneous direction of motion.

See J. D. Jackson, Classical Electrodynamics, 2nd edition (John Wiley & Sons, New York, 1975) for more formulae and details (Prepared April 1974; revised April 1980.)

RADIOACTIVITY AND RADIATION PROTECTION

Unit of activity = Curie:
 1 Ci = 3.7×10^{10} disintegrations/sec
Unit of exposure dose for x and γ radiation = Roentgen:
 1 R = 1 esu/cm^3 = 87.8 erg/g (5.49×10^7 MeV/g) of air
Unit of absorbed dose = rad:
 1 rad = 100 erg/g (6.25×10^7 MeV/g) in any material
Unit of dose equivalent (for protection) = rem:
 rems (Roentgen equivalents for man) = rads $\times$ QF,
where QF (quality factor) depends upon the type of radiation and other factors. For γ rays and HE protons, QF $\approx$ 1; for thermal neutrons, QF $\approx$ 3; for fast neutrons, QF ranges up to 10; and for α particles and heavy ions, QF ranges up to 20.

Maximum permissible occupational dose for the whole body:
 5 rem/year (maximum 3 rem/calendar quarter)
Fluxes (per cm^2) to liberate 1 rad in carbon:
 3.5×10^7 minimum ionizing singly charged particles
 1.0×10^9 photons of 1 MeV energy
(These fluxes are correct to within a factor of 2 for all materials.)
Natural background: 120 to 130 millirem/year
 cosmic radiation (charged particles + neutrons) ~25 mrem/yr
 cosmic radiation (γ rays) ~25 mrem/yr
 radiation from rocks and air (γ rays) ~73 mrem/yr
Cosmic ray background in counters: ~ 1/min/cm^2/ster

C.M. ENERGY AND MOMENTUM VS. BEAM MOMENTUM

$$E_{cm}dE_{cm} = m_p dT_{beam} = m_p v_{beam} dP_{beam} \approx m_p dP_{beam}$$

PBEAM (GEV/C)	C. M. ENERGY (GEV) γp, νp ≈ep	πp	Kp	pp	MOMENTUM IN C. M. (GEV/C) γp, νp ≈ep	πp	Kp	pp
0.00	.938	1.078	1.432	1.877	.000	.000	.000	.000
0.02	.958	1.079	1.432	1.877	.020	.017	.013	.010
0.04	.977	1.083	1.433	1.877	.038	.035	.026	.020
0.06	.996	1.089	1.434	1.878	.056	.052	.039	.030
0.08	1.015	1.096	1.436	1.878	.074	.068	.052	.040
0.10	1.033	1.105	1.439	1.879	.091	.085	.065	.050
0.12	1.051	1.116	1.441	1.880	.107	.101	.078	.060
0.14	1.069	1.127	1.445	1.882	.123	.117	.091	.070
0.16	1.087	1.139	1.448	1.883	.138	.132	.104	.080
0.18	1.104	1.152	1.453	1.885	.153	.147	.116	.090
0.20	1.121	1.165	1.457	1.887	.167	.161	.129	.099
0.22	1.137	1.178	1.462	1.889	.182	.175	.141	.109
0.24	1.154	1.192	1.468	1.892	.195	.189	.153	.119
0.26	1.170	1.206	1.473	1.894	.209	.202	.166	.129
0.28	1.186	1.219	1.480	1.897	.222	.215	.178	.138
0.30	1.201	1.233	1.486	1.900	.234	.228	.189	.148
0.32	1.217	1.247	1.493	1.903	.247	.241	.201	.158
0.34	1.232	1.261	1.500	1.906	.259	.253	.213	.167
0.36	1.247	1.275	1.507	1.910	.271	.265	.224	.177
0.38	1.262	1.288	1.514	1.913	.282	.277	.235	.186
0.40	1.277	1.302	1.522	1.917	.294	.288	.247	.196
0.42	1.292	1.315	1.530	1.921	.305	.300	.258	.205
0.44	1.306	1.329	1.538	1.925	.316	.311	.268	.214
0.46	1.320	1.342	1.546	1.929	.327	.322	.279	.224
0.48	1.335	1.356	1.554	1.934	.337	.332	.290	.233
0.50	1.349	1.369	1.563	1.938	.348	.343	.300	.242
0.52	1.362	1.382	1.571	1.943	.358	.353	.310	.251
0.54	1.376	1.395	1.580	1.947	.368	.363	.321	.260
0.56	1.390	1.408	1.589	1.952	.378	.373	.331	.269
0.58	1.403	1.421	1.598	1.957	.388	.383	.341	.278
0.60	1.416	1.434	1.607	1.962	.397	.393	.350	.287
0.62	1.430	1.447	1.616	1.968	.407	.402	.360	.296
0.64	1.443	1.459	1.625	1.973	.416	.412	.370	.304
0.66	1.456	1.472	1.634	1.978	.425	.421	.379	.313
0.68	1.468	1.484	1.643	1.984	.434	.430	.388	.322
0.70	1.481	1.496	1.653	1.989	.443	.439	.397	.330
0.72	1.494	1.509	1.662	1.995	.452	.448	.406	.339
0.74	1.506	1.521	1.671	2.001	.461	.457	.415	.347
0.76	1.519	1.533	1.681	2.007	.470	.465	.424	.355
0.78	1.531	1.545	1.690	2.013	.478	.474	.433	.364
0.80	1.543	1.557	1.699	2.019	.486	.482	.442	.372
0.82	1.555	1.569	1.709	2.025	.495	.490	.450	.380
0.84	1.567	1.580	1.718	2.031	.503	.499	.459	.388
0.86	1.579	1.592	1.728	2.037	.511	.507	.467	.396
0.88	1.591	1.604	1.737	2.043	.519	.515	.475	.404
0.90	1.603	1.615	1.747	2.050	.527	.523	.484	.412
0.92	1.615	1.627	1.756	2.056	.535	.531	.492	.420
0.94	1.626	1.638	1.765	2.062	.542	.538	.500	.428
0.96	1.638	1.649	1.775	2.069	.550	.546	.508	.435
0.98	1.649	1.661	1.784	2.075	.558	.554	.515	.443
1.00	1.660	1.672	1.794	2.082	.565	.561	.523	.451
1.02	1.672	1.683	1.803	2.088	.573	.569	.531	.458
1.04	1.683	1.694	1.812	2.095	.580	.576	.538	.466
1.06	1.694	1.705	1.822	2.102	.587	.583	.546	.473
1.08	1.705	1.716	1.831	2.108	.594	.591	.553	.481
1.10	1.716	1.726	1.840	2.115	.601	.598	.561	.488
1.12	1.727	1.737	1.850	2.122	.609	.605	.568	.495
1.14	1.738	1.748	1.859	2.129	.616	.612	.575	.502
1.16	1.748	1.759	1.868	2.136	.622	.619	.583	.510
1.18	1.759	1.769	1.877	2.142	.629	.626	.590	.517
1.20	1.770	1.780	1.887	2.149	.636	.633	.597	.524
1.22	1.780	1.790	1.896	2.156	.643	.639	.604	.531
1.24	1.791	1.800	1.905	2.163	.650	.646	.611	.538
1.26	1.801	1.811	1.914	2.170	.656	.653	.618	.545
1.28	1.812	1.821	1.923	2.177	.663	.660	.624	.552
1.30	1.822	1.831	1.932	2.184	.669	.666	.631	.559
1.32	1.832	1.841	1.941	2.191	.676	.673	.638	.565
1.34	1.843	1.851	1.950	2.198	.682	.679	.645	.572
1.36	1.853	1.862	1.959	2.205	.689	.685	.651	.579
1.38	1.863	1.872	1.968	2.212	.695	.692	.658	.585
1.40	1.873	1.882	1.977	2.219	.701	.698	.664	.592
1.42	1.883	1.891	1.986	2.226	.708	.704	.671	.599
1.44	1.893	1.901	1.995	2.233	.714	.711	.677	.605
1.46	1.903	1.911	2.004	2.240	.720	.717	.684	.612
1.48	1.913	1.921	2.013	2.247	.726	.723	.690	.618
1.50	1.922	1.931	2.022	2.254	.732	.729	.696	.624
1.52	1.932	1.940	2.031	2.261	.738	.735	.702	.631
1.54	1.942	1.950	2.039	2.268	.744	.741	.709	.637
1.56	1.951	1.959	2.048	2.275	.750	.747	.715	.643
1.58	1.961	1.969	2.057	2.282	.756	.753	.721	.650
1.60	1.970	1.978	2.065	2.289	.762	.759	.727	.656
1.62	1.980	1.988	2.074	2.296	.768	.765	.733	.662
1.64	1.989	1.997	2.083	2.304	.773	.770	.739	.668
1.66	1.999	2.006	2.091	2.311	.779	.776	.745	.674
1.68	2.008	2.016	2.100	2.318	.785	.782	.751	.680

PBEAM (GEV/C)	C. M. ENERGY (GEV) γp, νp ≈ep	πp	Kp	pp	MOMENTUM IN C. M. (GEV/C) γp, νp ≈ep	πp	Kp	pp
1.70	2.018	2.025	2.109	2.325	.791	.788	.756	.686
1.72	2.027	2.034	2.117	2.332	.796	.793	.762	.692
1.74	2.036	2.043	2.126	2.339	.802	.799	.768	.698
1.76	2.045	2.053	2.134	2.346	.807	.805	.774	.704
1.78	2.054	2.062	2.143	2.353	.813	.810	.780	.710
1.80	2.064	2.071	2.151	2.360	.818	.816	.785	.716
1.82	2.073	2.080	2.159	2.367	.824	.821	.791	.721
1.84	2.082	2.089	2.168	2.374	.829	.827	.796	.727
1.86	2.091	2.098	2.176	2.381	.835	.832	.802	.733
1.88	2.100	2.107	2.184	2.388	.840	.837	.808	.739
1.90	2.109	2.115	2.193	2.395	.845	.843	.813	.744
1.92	2.117	2.124	2.201	2.402	.851	.848	.819	.750
1.94	2.126	2.133	2.209	2.409	.856	.853	.824	.756
1.96	2.135	2.142	2.217	2.416	.861	.859	.829	.761
1.98	2.144	2.151	2.226	2.423	.867	.864	.835	.767
2.0	2.153	2.159	2.234	2.430	.872	.869	.840	.772
2.1	2.196	2.202	2.274	2.465	.897	.895	.866	.799
2.2	2.238	2.244	2.314	2.500	.922	.920	.892	.826
2.3	2.280	2.286	2.353	2.534	.947	.944	.917	.852
2.4	2.320	2.326	2.392	2.568	.970	.968	.941	.877
2.5	2.360	2.366	2.430	2.602	.994	.991	.965	.901
2.6	2.400	2.405	2.468	2.636	1.02	1.01	.989	.926
2.7	2.439	2.444	2.505	2.669	1.04	1.04	1.01	.949
2.8	2.477	2.482	2.542	2.702	1.06	1.06	1.03	.972
2.9	2.514	2.520	2.578	2.735	1.08	1.08	1.06	.995
3.0	2.551	2.556	2.613	2.768	1.10	1.10	1.08	1.02
3.1	2.588	2.593	2.649	2.800	1.12	1.12	1.10	1.04
3.2	2.624	2.629	2.683	2.832	1.14	1.14	1.12	1.06
3.3	2.660	2.664	2.718	2.863	1.16	1.16	1.14	1.08
3.4	2.695	2.699	2.752	2.895	1.18	1.18	1.16	1.10
3.5	2.729	2.734	2.785	2.926	1.20	1.20	1.18	1.12
3.6	2.763	2.768	2.818	2.957	1.22	1.22	1.20	1.14
3.7	2.797	2.801	2.851	2.987	1.24	1.24	1.22	1.16
3.8	2.830	2.835	2.884	3.018	1.26	1.26	1.24	1.18
3.9	2.863	2.868	2.916	3.048	1.28	1.28	1.26	1.20
4.0	2.896	2.900	2.947	3.077	1.30	1.29	1.27	1.22
4.1	2.928	2.932	2.979	3.107	1.31	1.31	1.29	1.24
4.2	2.960	2.964	3.010	3.136	1.33	1.33	1.31	1.26
4.3	2.992	2.996	3.041	3.165	1.35	1.35	1.33	1.27
4.4	3.023	3.027	3.071	3.194	1.37	1.36	1.34	1.29
4.5	3.054	3.058	3.101	3.223	1.38	1.38	1.36	1.31
4.6	3.084	3.088	3.131	3.251	1.40	1.40	1.38	1.33
4.7	3.115	3.118	3.161	3.279	1.42	1.41	1.40	1.34
4.8	3.144	3.148	3.190	3.307	1.43	1.43	1.41	1.36
4.9	3.174	3.178	3.220	3.335	1.45	1.45	1.43	1.38
5.0	3.204	3.207	3.248	3.363	1.46	1.46	1.44	1.40
5.2	3.262	3.265	3.305	3.417	1.50	1.49	1.48	1.43
5.4	3.319	3.322	3.362	3.471	1.53	1.53	1.51	1.46
5.6	3.375	3.378	3.417	3.524	1.56	1.56	1.54	1.49
5.8	3.430	3.433	3.471	3.576	1.59	1.59	1.57	1.52
6.0	3.484	3.487	3.524	3.627	1.62	1.61	1.60	1.55
6.2	3.538	3.541	3.577	3.678	1.64	1.64	1.63	1.58
6.4	3.590	3.593	3.629	3.728	1.67	1.67	1.65	1.61
6.6	3.642	3.645	3.680	3.778	1.70	1.70	1.68	1.64
6.8	3.693	3.696	3.731	3.827	1.73	1.73	1.71	1.67
7.0	3.744	3.747	3.781	3.875	1.75	1.75	1.74	1.70
7.2	3.794	3.797	3.830	3.923	1.78	1.78	1.76	1.72
7.4	3.843	3.846	3.878	3.970	1.81	1.81	1.79	1.75
7.6	3.891	3.894	3.926	4.016	1.83	1.83	1.82	1.78
7.8	3.939	3.942	3.974	4.062	1.86	1.86	1.84	1.80
8.0	3.987	3.989	4.021	4.108	1.88	1.88	1.87	1.83
8.2	4.033	4.036	4.067	4.153	1.91	1.91	1.89	1.85
8.4	4.080	4.082	4.113	4.198	1.93	1.93	1.92	1.88
8.6	4.125	4.128	4.158	4.242	1.96	1.95	1.94	1.90
8.8	4.171	4.173	4.203	4.286	1.98	1.98	1.96	1.93
9.0	4.215	4.218	4.247	4.329	2.00	2.00	1.99	1.95
9.2	4.260	4.262	4.291	4.372	2.03	2.03	2.01	1.97
9.4	4.303	4.306	4.335	4.415	2.05	2.05	2.03	2.00
9.6	4.347	4.349	4.378	4.457	2.07	2.07	2.06	2.02
9.8	4.390	4.392	4.420	4.498	2.09	2.09	2.08	2.04
10.0	4.432	4.435	4.462	4.540	2.12	2.12	2.10	2.07
10.5	4.537	4.539	4.566	4.641	2.17	2.17	2.16	2.12
11.0	4.639	4.642	4.668	4.741	2.22	2.22	2.21	2.18
11.5	4.739	4.742	4.767	4.839	2.28	2.28	2.26	2.23
12.0	4.837	4.839	4.864	4.934	2.33	2.33	2.31	2.28
12.5	4.933	4.935	4.960	5.028	2.38	2.38	2.36	2.33
13.0	5.027	5.030	5.053	5.120	2.43	2.43	2.41	2.38
13.5	5.120	5.122	5.145	5.211	2.47	2.47	2.46	2.43
14.0	5.211	5.213	5.236	5.300	2.52	2.52	2.51	2.48
14.5	5.300	5.302	5.324	5.388	2.57	2.57	2.56	2.53
15.0	5.388	5.390	5.412	5.474	2.61	2.61	2.60	2.57
15.5	5.474	5.476	5.498	5.559	2.66	2.66	2.65	2.62
16.0	5.559	5.561	5.582	5.642	2.70	2.70	2.69	2.66
16.5	5.643	5.645	5.666	5.725	2.74	2.74	2.73	2.70
17.0	5.726	5.727	5.748	5.806	2.79	2.79	2.78	2.75

PBEAM (GEV/C)	C. M. ENERGY (GEV) γp, νp ≈ep	πp	Kp	pp	MOMENTUM IN C. M. (GEV/C) γp, νp ≈ep	πp	Kp	pp
17.5	5.807	5.809	5.829	5.886	2.83	2.83	2.82	2.79
18.0	5.887	5.889	5.909	5.965	2.87	2.87	2.86	2.83
18.5	5.966	5.968	5.988	6.043	2.91	2.91	2.90	2.87
19.0	6.044	6.046	6.066	6.120	2.95	2.95	2.94	2.91
19.5	6.122	6.123	6.142	6.196	2.99	2.99	2.98	2.95
20	6.198	6.199	6.218	6.272	3.03	3.03	3.02	2.99
21	6.347	6.349	6.367	6.419	3.10	3.10	3.09	3.07
22	6.493	6.495	6.513	6.564	3.18	3.18	3.17	3.14
23	6.636	6.638	6.655	6.705	3.25	3.25	3.24	3.22
24	6.776	6.778	6.795	6.843	3.32	3.32	3.31	3.29
25	6.913	6.915	6.932	6.979	3.39	3.39	3.38	3.36
26	7.048	7.049	7.066	7.112	3.46	3.46	3.45	3.43
27	7.180	7.181	7.197	7.243	3.53	3.53	3.52	3.50
28	7.309	7.311	7.326	7.371	3.59	3.59	3.59	3.56
29	7.436	7.438	7.453	7.497	3.66	3.66	3.65	3.63
30	7.562	7.563	7.578	7.621	3.72	3.72	3.71	3.69
31	7.685	7.686	7.701	7.743	3.79	3.78	3.78	3.76
32	7.806	7.807	7.822	7.864	3.85	3.85	3.84	3.82
33	7.925	7.926	7.941	7.982	3.91	3.91	3.90	3.88
34	8.043	8.044	8.058	8.099	3.97	3.97	3.96	3.94
35	8.158	8.160	8.174	8.214	4.03	4.02	4.02	4.00
36	8.273	8.274	8.288	8.327	4.08	4.08	4.08	4.06
37	8.385	8.386	8.400	8.439	4.14	4.14	4.13	4.11
38	8.496	8.498	8.511	8.549	4.20	4.20	4.19	4.17
39	8.606	8.607	8.621	8.658	4.25	4.25	4.24	4.23
40	8.715	8.716	8.729	8.766	4.31	4.31	4.30	4.28
41	8.822	8.823	8.836	8.872	4.36	4.36	4.35	4.34
42	8.927	8.928	8.941	8.978	4.41	4.41	4.41	4.39
43	9.032	9.033	9.046	9.081	4.47	4.47	4.46	4.44
44	9.135	9.136	9.149	9.184	4.52	4.52	4.51	4.50
45	9.237	9.238	9.251	9.286	4.57	4.57	4.56	4.55
46	9.338	9.339	9.352	9.386	4.62	4.62	4.62	4.60
47	9.438	9.439	9.451	9.486	4.67	4.67	4.67	4.65
48	9.537	9.538	9.550	9.584	4.72	4.72	4.72	4.70
49	9.635	9.636	9.648	9.681	4.77	4.77	4.77	4.75
50	9.732	9.733	9.745	9.778	4.82	4.82	4.81	4.80
52	9.923	9.924	9.935	9.968	4.92	4.92	4.91	4.89
54	10.11	10.11	10.12	10.15	5.01	5.01	5.01	4.99
56	10.29	10.30	10.31	10.34	5.10	5.10	5.10	5.08
58	10.47	10.48	10.49	10.52	5.20	5.19	5.19	5.17
60	10.65	10.65	10.66	10.69	5.28	5.28	5.28	5.26
62	10.83	10.83	10.84	10.87	5.37	5.37	5.37	5.35
64	11.00	11.00	11.01	11.04	5.46	5.46	5.45	5.44
66	11.17	11.17	11.18	11.21	5.54	5.54	5.54	5.53
68	11.34	11.34	11.35	11.37	5.63	5.63	5.62	5.61
70	11.50	11.50	11.51	11.54	5.71	5.71	5.71	5.69
72	11.66	11.66	11.67	11.70	5.79	5.79	5.79	5.77
74	11.82	11.82	11.83	11.86	5.87	5.87	5.87	5.85
76	11.98	11.98	11.99	12.02	5.95	5.95	5.95	5.93
78	12.13	12.14	12.14	12.17	6.03	6.03	6.03	6.01
80	12.29	12.29	12.30	12.32	6.11	6.11	6.10	6.09
82	12.44	12.44	12.45	12.48	6.18	6.18	6.18	6.17
84	12.59	12.59	12.60	12.63	6.26	6.26	6.26	6.24
86	12.74	12.74	12.75	12.77	6.33	6.33	6.33	6.32
88	12.88	12.89	12.89	12.92	6.41	6.41	6.40	6.39
90	13.03	13.03	13.04	13.06	6.48	6.48	6.48	6.46
92	13.17	13.17	13.18	13.21	6.55	6.55	6.55	6.54
94	13.31	13.32	13.32	13.35	6.62	6.62	6.62	6.61
96	13.45	13.46	13.46	13.49	6.69	6.69	6.69	6.68
98	13.59	13.59	13.60	13.63	6.76	6.76	6.76	6.75
100	13.73	13.73	13.74	13.76	6.83	6.83	6.83	6.82
150	16.80	16.80	16.81	16.83	8.38	8.38	8.37	8.36
200	19.40	19.40	19.40	19.42	9.68	9.67	9.67	9.66
250	21.68	21.68	21.69	21.70	10.8	10.8	10.8	10.8
300	23.75	23.75	23.75	23.76	11.9	11.9	11.9	11.8
350	25.65	25.65	25.65	25.66	12.8	12.8	12.8	12.8
400	27.41	27.41	27.42	27.43	13.7	13.7	13.7	13.7
450	29.07	29.07	29.08	29.09	14.5	14.5	14.5	14.5
500	30.65	30.65	30.65	30.66	15.3	15.3	15.3	15.3
550	32.14	32.14	32.14	32.15	16.1	16.1	16.1	16.0
600	33.57	33.57	33.57	33.58	16.8	16.8	16.8	16.8
650	34.94	34.94	34.94	34.95	17.5	17.5	17.5	17.4
700	36.26	36.26	36.26	36.27	18.1	18.1	18.1	18.1
750	37.53	37.53	37.53	37.54	18.8	18.8	18.8	18.7
800	38.76	38.76	38.76	38.77	19.4	19.4	19.4	19.4
850	39.95	39.95	39.95	39.96	20.0	20.0	20.0	20.0
900	41.11	41.11	41.11	41.12	20.5	20.5	20.5	20.5
950	42.23	42.23	42.24	42.24	21.1	21.1	21.1	21.1
1000	43.33	43.33	43.33	43.34	21.7	21.7	21.7	21.6
2000	61.27	61.27	61.27	61.28	30.6	30.6	30.6	30.6
5000	96.87	96.87	96.87	96.87	48.4	48.4	48.4	48.4
10000	137.0	137.0	137.0	137.0	68.5	68.5	68.5	68.5
20000	193.7	193.7	193.7	193.7	96.9	96.9	96.9	96.9
50000	306.3	306.3	306.3	306.3	153	153	153	153
100000	433.2	433.2	433.2	433.2	217	217	217	217
200000	612.6	612.6	612.6	612.6	306	306	306	306
500000	968.6	968.6	968.6	968.6	484	484	484	484
1000000	1370	1370	1370	1370	685	685	685	685

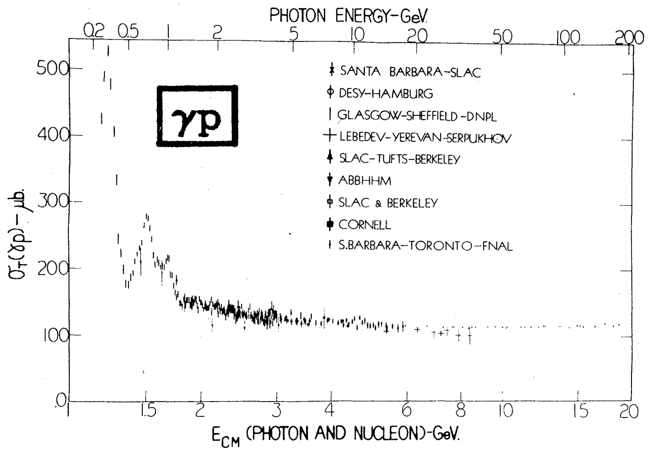
PERIODIC TABLE OF THE ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	
								1 H 1.0079									2 He 4.00260
3 Li 6.94	4 Be 9.01218											5 B 10.81	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.998403	10 Ne 20.17
11 Na 22.98977	12 Mg 24.305											13 Al 26.98154	14 Si 28.0855	15 P 30.97376	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.0983	20 Ca 40.08	21 Sc 44.9559	22 Ti 47.90	23 V 50.9415	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.546	30 Zn 65.38	31 Ga 69.735	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.467	38 Sr 87.62	39 Y 88.9059	40 Zr 91.22	41 Nb 92.9064	42 Mo 95.94	43 Tc 98.9062	44 Ru 101.07	45 Rh 102.9055	46 Pd 106.4	47 Ag 107.868	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.9045	54 Xe 131.30
55 Cs 132.9054	56 Ba 137.33	57–71 Rare Earths	72 Hf 178.49	73 Ta 180.947	74 W 183.85	75 Re 186.207	76 Os 190.2	77 Ir 192.22	78 Pt 195.09	79 Au 196.9665	80 Hg 200.59	81 Tl 204.37	82 Pb 207.2	83 Bi 208.9804	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0254	89– Acti- nides	104 (260)	105 (260)	106 (263)												

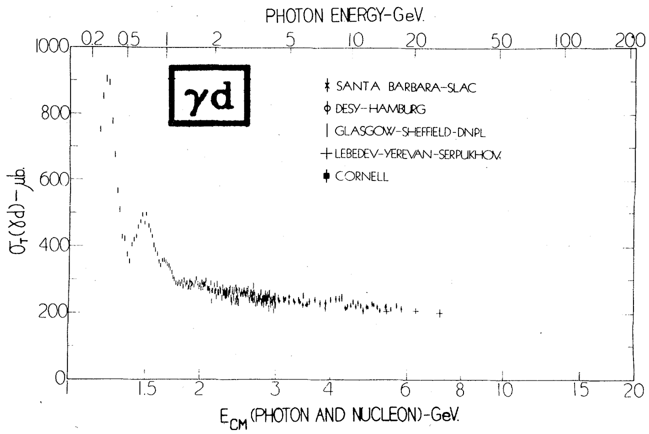
57 La 138.9055	58 Ce 140.12	59 Pr 140.9077	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.9254	66 Dy 162.50	67 Ho 164.9304	68 Er 167.26	69 Tm 168.9342	70 Yb 173.04	71 Lu 174.967	Rare earths (Lanthanide series)
89 Ac (227)	90 Th 232.0381	91 Pa 231.0359	92 U 238.029	93 Np 237.0482	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)	Actinide series

Upper number is atomic number, expressing the positive charge of the nucleus in multiples of the electronic charge e. Lower number is atomic mass weighted by isotopic abundance in earth's surface, relative to the mass of the carbon 12 isotope, which has been arbitrarily assigned a mass of 12.00000 atomic mass units (amu). Numbers in parentheses are mass numbers (the whole number nearest the value of the atomic mass, in amu) of most stable isotope of that element. Adapted from the Handbook of Chemistry and Physics, 60th Ed., 1979-1980. (Particle Data Group update, April 1980.)

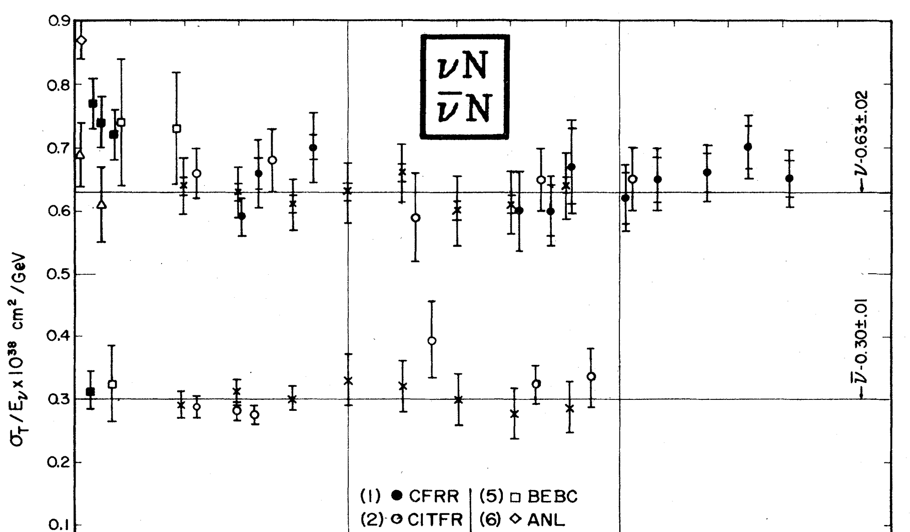
CROSS SECTION PLOTS



γp total cross section versus photon energy (top scale) and photon-plus-nucleon total center-of-mass energy (lower scale). References: SANTA BARBARA-SLAC: D.O.Caldwell et al., Phys. Rev. D7, 1362 (1973); DESY-HAMBURG: H.Meyer et al., Phys. Lett. 33B, 189 (1970); GLASGOW-SHEFFIELD-DNPL: T.A.Armstrong et al., Phys. Rev. D5, 1640 (1972); LEBEDEV-YEREVAN-SERPUKHOV: A.S.Belousov et al., Preprint 19, Moscow (1973), A.S.Belousov et al., Sov. Phys. Doklady 19, 123 (1974), and A.S.Belousov et al., Sov. J. Nucl. Phys. 21(3), 289 (1975); SLAC-BERKELEY-TUFTS: J.Ballam et al., Phys. Rev. D5, 545 (1972); ABBHHM: H.G.Hilpert et al., Phys. Lett. 27B, 474 (1968); SLAC and BERKELEY: J.Ballam et al., Phys. Rev. Lett. 21, 1544 (1968), and H.H.Bingham et al., Phys. Rev. D8, 1277 (1973); CORNELL: S.Michalowski et al., Phys. Rev. Lett. 39, 737 (1977); SANTA BARBARA-TORONTO-FNAL: D.O.Caldwell et al., Phys. Rev. Lett. 40, 1222 (1978). Courtesy Gething M. Lewis, Glasgow.



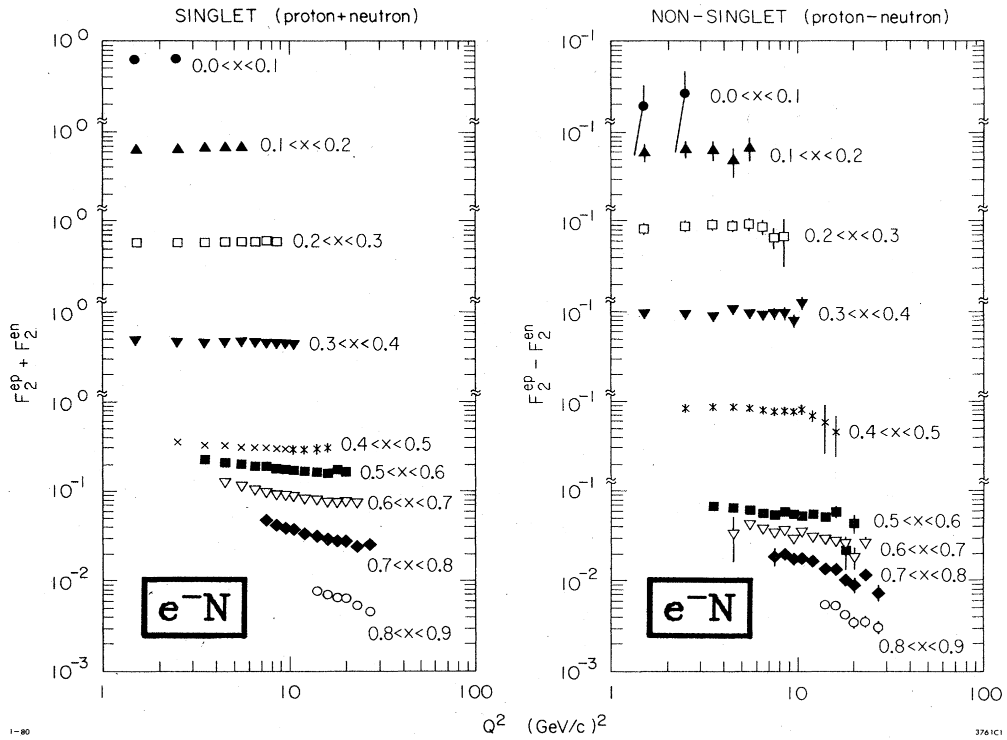
γd total cross section versus photon energy (top scale) and photon-plus-single-nucleon total center-of-mass energy (lower scale). References: SANTA BARBARA-SLAC: D.O.Caldwell et al., Phys. Rev. D7, 1362 (1973); DESY-HAMBURG: H.Meyer et al., Phys. Lett. 33B, 189 (1970); GLASGOW-SHEFFIELD-DNPL: T.A.Armstrong et al., Nucl. Phys. B41, 445 (1972); LEBEDEV-YEREVAN-SERPUKHOV: A.S.Belousov et al., Sov. J. Nucl. Phys. 21(3), 289 (1975); CORNELL: S.Michalowski et al., Phys. Rev. Lett. 39, 737 (1977). Courtesy Gething M. Lewis, Glasgow.



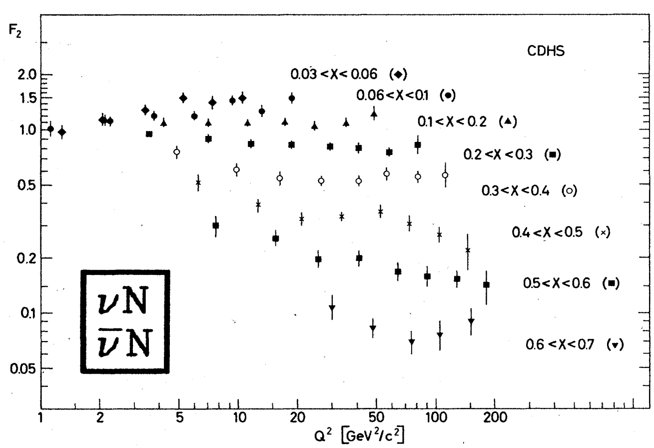
σ_T/E_ν for the muon neutrino and antineutrino charged-current total cross section as a function of neutrino energy. The straight lines are averages of all data. (1) B.Barish et al., Cal Tech preprint CALT 68-734 (1979); (2) B.C.Barish et al., Phys. Rev. Lett. 39, 1595 (1977); (3) J.G.H.de Groot et al., Z. Physik C - Particles and Fields 1, 143 (1979); (4) S.Ciampolillo et al., Phys. Lett. 84B, 281 (1979); (5) D.C.Colley et al., Z. Physik C - Particles and Fields 2, 187 (1979); (6) S.J.Barish et al., Phys. Rev. D19, 2521 (1979); (7) A.E.Asratyan et al., Phys. Lett. 76B, 239 (1978), and A.E.Muklin, Serpukhov preprint SERP-4-45 (1979). Courtesy D. Theriot, FNAL.

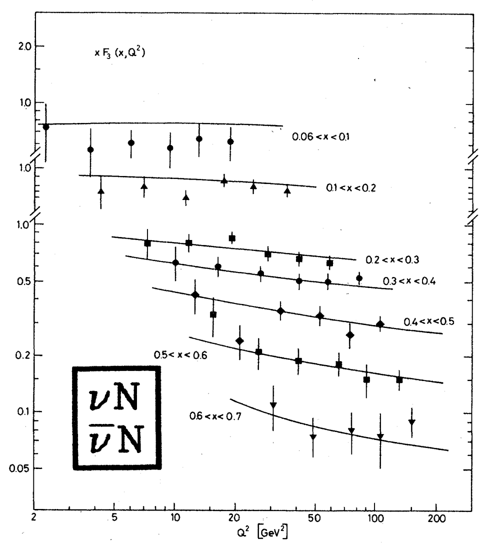
CROSS SECTION PLOTS (Cont'd)

Structure Functions



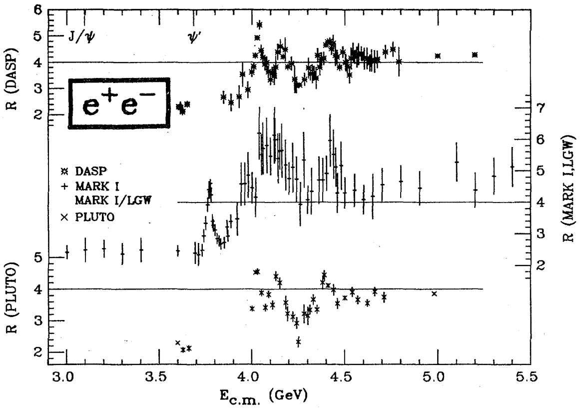
F_2 structure functions derived from inelastic electron-nucleon data taken at SLAC[1-4] with recoil mass >2 GeV and four-momentum transfer squared $Q^2 > 1(\text{GeV}/c)^2$ are shown. For definitions of F_2, x, and Q^2, see the "Relativistic Kinematics" section and the "Weak Interactions of Quarks and Leptons" section. $R \equiv \sigma_L/\sigma_T = 0.21$ [3] was assumed. Systematic errors are comparable in size to the data point symbols. Corrections for nucleon motion in deuterium have been made. These corrections are small except for $x > 0.7$. No error was included to account for uncertainties in this correction. References: 1) A.Bodek et al., Phys. Rev. D20, 1471 (1979); 2) W.B.Atwood, SLAC Report No. 185 (1975); 3) M.D.Mestayer, SLAC Report No. 214 (1978); 4) S.Stein et al., Phys. Rev. D12, 1884 (1975). Courtesy W. B. Atwood, SLAC.



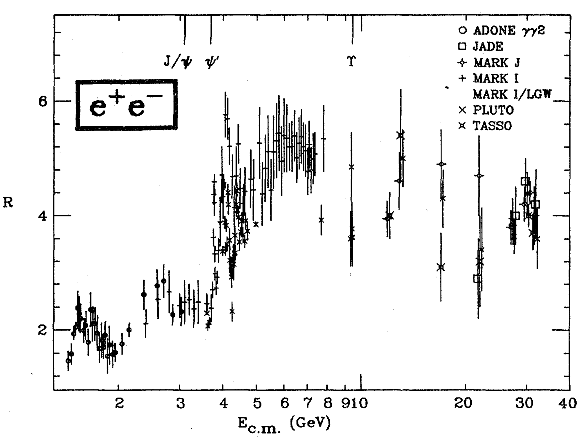


Nucleon structure functions as measured by the CDHS collaboration in high energy (30-200 GeV) charged-current neutrino- and anti-neutrino-nucleon scattering [J.G.H.de Groot et al., Z. Physik C - Particles and Fields 1, 143 (1979); reproduced by permission]. Definitions, and a discussion of the significance of these structure functions, may be found in the above reference, and also in the "Weak Interactions of Quarks and Leptons" section of the present work. See de Groot et al., for a discussion of experimental details, including corrections, etc. Curves are based on a QCD parametrization of Buras and Gaemers [Nucl. Phys. B132, 249 (1978)].

CROSS SECTION PLOTS (Cont'd)



An expanded view of R measurements around charm threshold. See the caption for the figure below for details (we have not combined any data points in this figure). We have arbitrarily added a horizontal line at R=4 as an aid to visual comparison of the three sets of data.

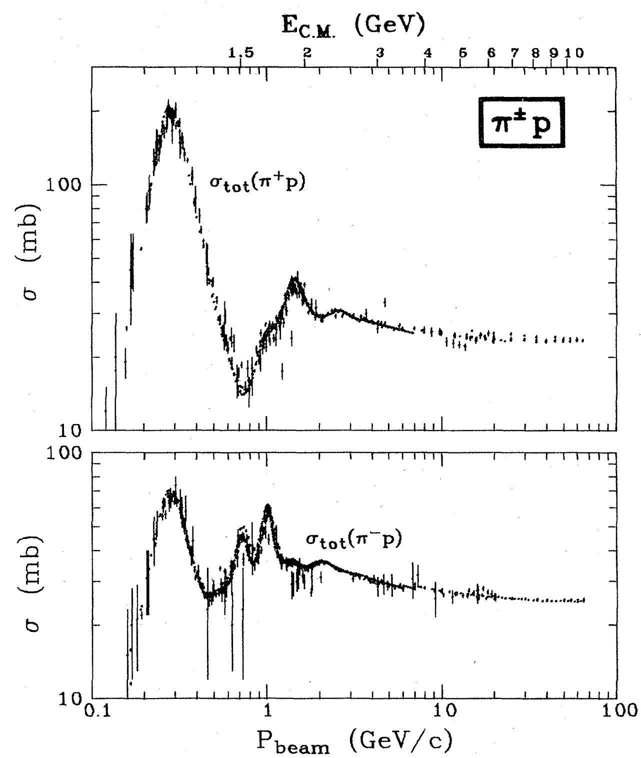


Measurements of $R \equiv \sigma(e^+e^- \to \text{hadrons})/\sigma(e^+e^- \to \mu^+\mu^-)$, where the annihilation proceeds via one photon. The denominator is a calculated quantity:

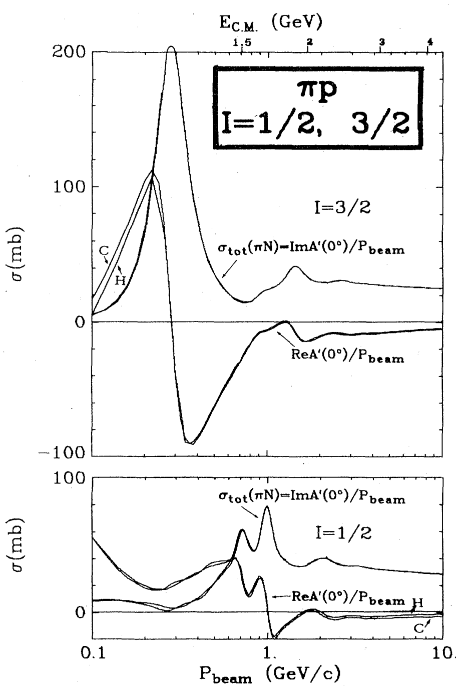
$$\sigma(e^+e^- \to \ell^+\ell^-) = (\hbar c)^2 \frac{\alpha^2}{4E_{cm}^2} \beta_\ell \int_{(4\pi)} d\Omega_{cm} (2 - \beta_\ell^2 \sin^2\theta_{cm})$$

$$\underset{\beta_\ell \to 1}{=} \frac{4\pi}{3} (\hbar c)^2 \frac{\alpha^2}{E_{cm}^2} = \frac{86.8}{[E_{cm}(\text{GeV})]^2}\ \text{nb} \ ; \quad \beta_\ell = \frac{p_\ell^{cm}}{E_\ell^{cm}} \ ;$$

for $e^+e^- \to \mu^+\mu^-$, $\beta_\mu \cong 1$ for energies shown. Radiative corrections and, where important, corrections for two-photon processes have been made. The J/ψ, ψ', and ϒ values are offscale at the positions indicated. Note the suppressed zero. The ADONE data is for ⩾3 hadrons only, and the points in the ψ" region are from the MARK I - Lead Glass Wall (LGW) experiment. For clarity, some of the data points for $E_{cm} < 10$ GeV have been combined by us, and some of the points above 10 GeV have been shifted slightly (<2%) in E_{cm}. Systematic errors (not included in the figure) are typically between 10% and 20%. The horizontal extent of the plot symbols has no special significance. References: ADONE γγ2: C.Bacci et al., PL 86B, 234 (1979); DASP: R.Brandelik et al., PL 76B, 361 (1978); JADE: W.Bartel et al., PL 88B, 171 (1979); MARK J: D.P. Barber et al., MIT Laboratory for Nuclear Science report #107 (1979), submitted to Nucl. Phys. B, H.Newman (private communication); MARK I: J.-E.Augustin et al., PRL 34, 764 (1975), W.Chinowsky, Ann. Rev. Nucl. Sci. 27, 393 (1977); MARK I + Lead Glass Wall: P.A.Rapidis et al., PRL 39, 526 (1977), P.A.Rapidis, Thesis, SLAC-Report-220 (1979); PLUTO: A.Bäcker, Thesis, Gesamthochschule Siegen, DESY F33-77/03, C.Gerke, Thesis, Hamburg University (1979), Ch.Berger et al., PL 81B, 410 (1979), Ch.Berger et al., PL 86B, 413 (1979); TASSO: R.Brandelik et al., DESY 79/74 (1979), submitted to Physics Letters. Courtesy F.C.Porter, Cal Tech.

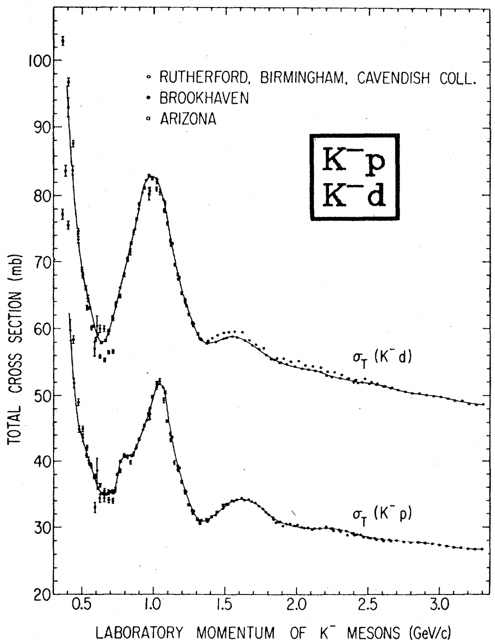


$\pi^{\pm}p$ total cross-section data from the Particle Data Group compilation "πN Two-Body Scattering Data," LBL-63 (1973).

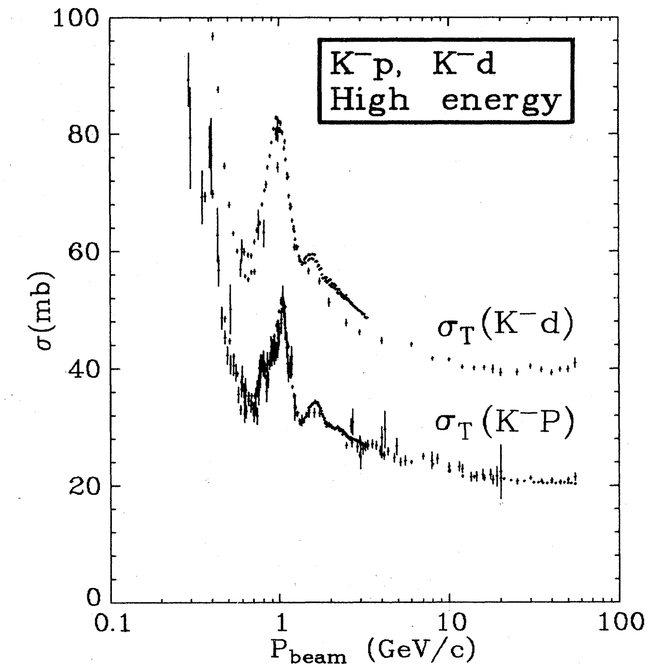


Interpolations of πN total cross sections for I = 3/2 and 1/2, and the corresponding real parts of the forward amplitudes as calculated from dispersion relations by A. A. Carter and J. R. Carter (RHEL preprint RL-73-024, 1973; labeled C above), and by G. Höhler and H. P. Jakob (private communication, 1972; labeled H above). The normalization of the curves for each value of I is such that the sum of their squares divided by 19.6 gives dσ/dt at 0° in $\text{mb}/(\text{GeV}/c)^2$. For visual purposes, these old analyses are fine; for quantitative purposes, refer to G. Höhler et al., Handbook of Pion-Nucleon Scattering, Physik Daten Series No. 12-1 (1979), Fachinformationzentrum, Karlsruhe, Germany.

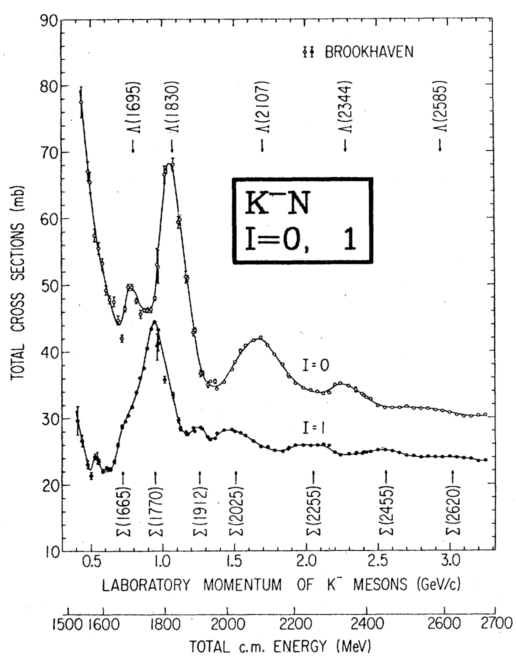
CROSS SECTION PLOTS (Cont'd)



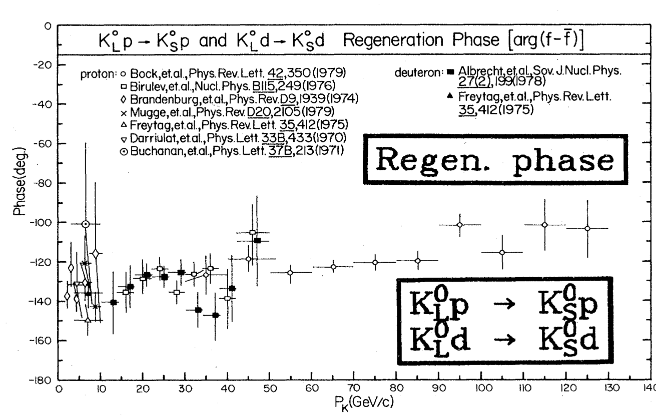
K^-p and K^-d total cross-section data compiled by Li et al., Proc. 1973 Purdue Conf. on Baryon Resonances. The solid curve passes through the Brookhaven data.



K^-p and K^-d total cross-section data. Compilation sources: E. Bracci et al., CERN/HERA 72-2, K^-p; G.R. Lynch, K^-d (<3 GeV/c); Particle Data Group, K^-d (>3 GeV/c). The BNL data below 1 GeV/c are not included.

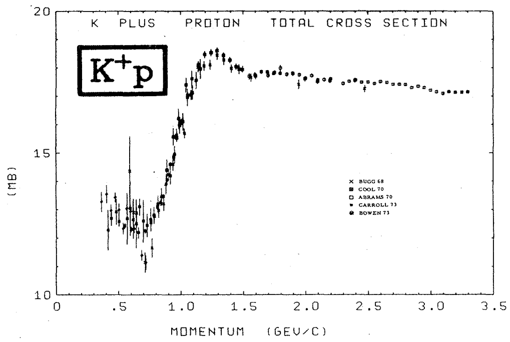


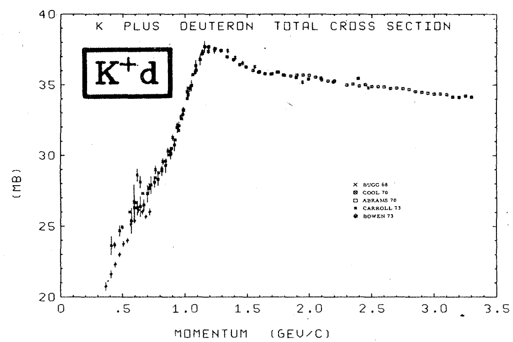
K^-N total cross sections for I=0 and I=1 below 3.3 GeV/c. Compiled and unfolded by Li et al., Proc. 1973 Purdue Conf. on Baryon Resonances.



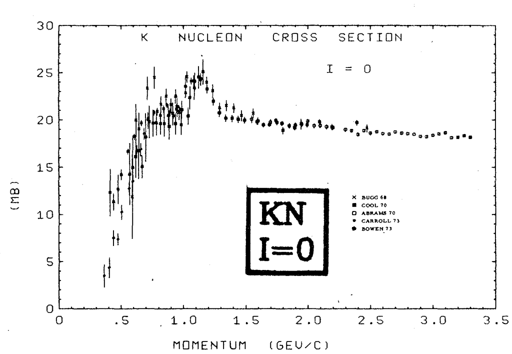
Phases of forward amplitudes for $K_L^0p \rightarrow K_S^0p$ (open symbols) and $K_L^0d \rightarrow K_S^0d$ (solid symbols). Courtesy S.Aronson, Brookhaven National Laboratory.

CROSS SECTION PLOTS (Cont'd)

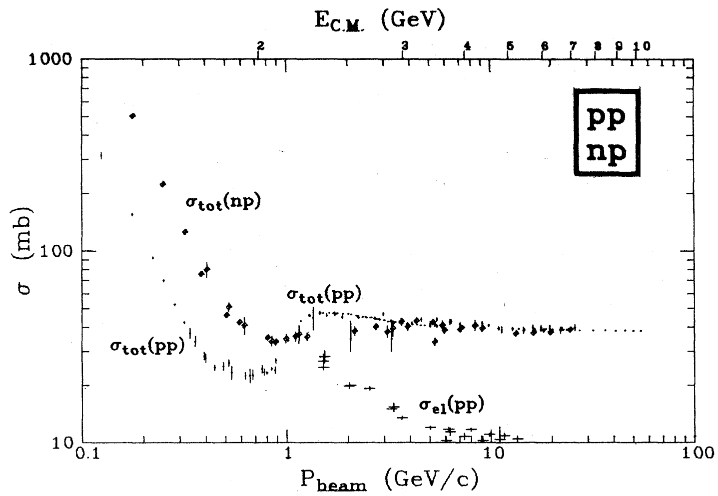




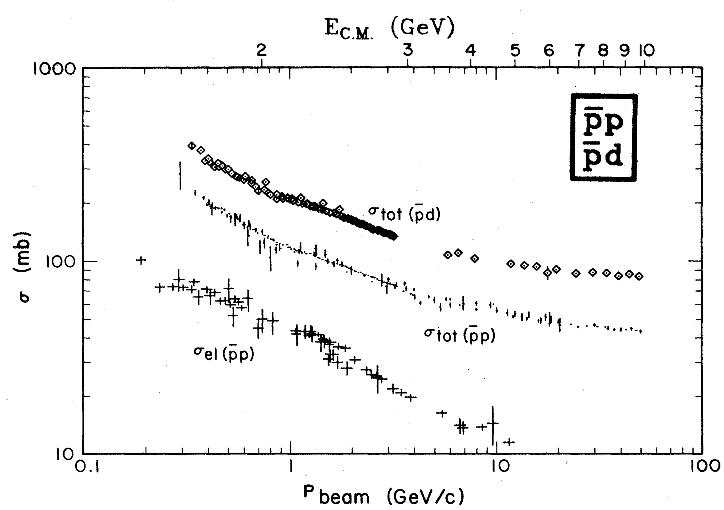
Compilation of K^+p and K^+d total cross-section measurements. References can be found in the Baryon Data Card Listings.



Total cross section for isospin zero KN system. Unfolding of the BUGG 68 and BOWEN 70 and 73 data was done by G. R. Lynch (as in Proc. of 1970 Duke Conference). Tables of σ_0 were provided by the BNL authors. Lynch and BNL use the same method of unfolding; the BOWEN 73 unfolded distribution is obtained by a different method [see plot in Z* mini-review in the 1976 edition of this review, Particle Data Group, Rev. Mod. Phys. 48, 1 (1976)].



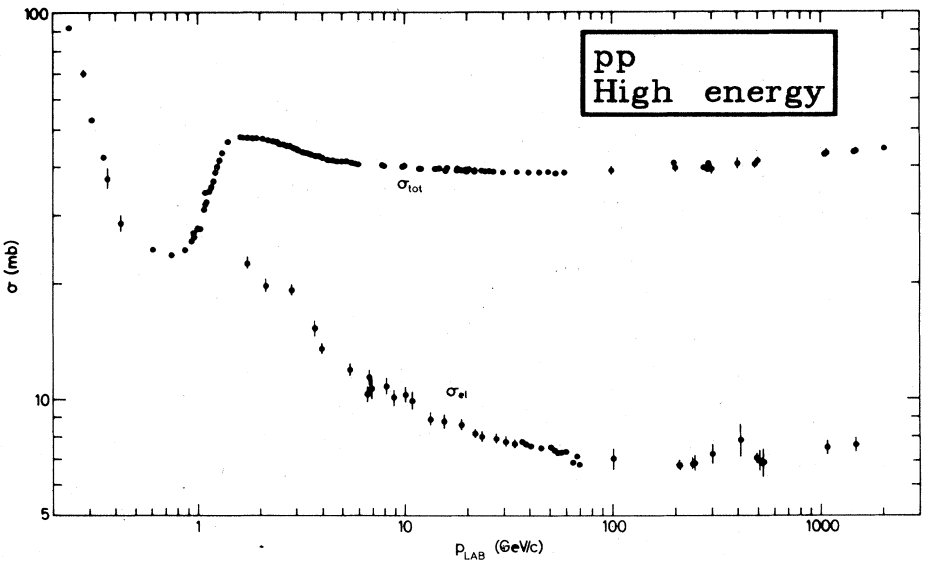
pp and np cross sections from Particle Data Group, "NN and ND Interactions -- A Compilation", UCRL-20 000 NN (August 1970); some points at higher energies added since original compilation.



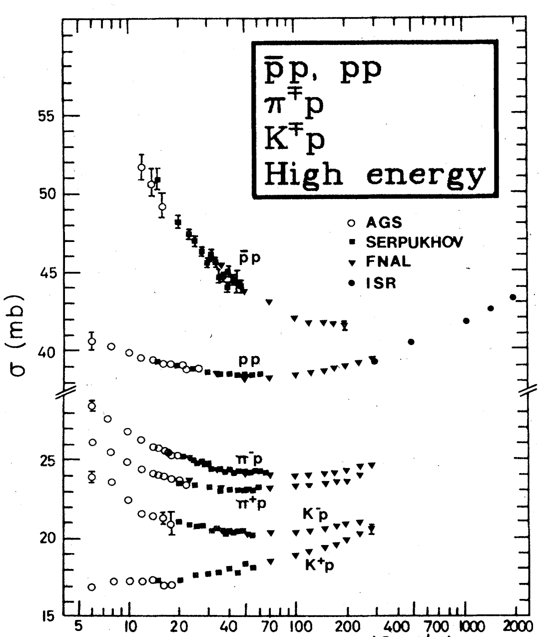
XBL 743-2661

$\bar{p}p$ and $\bar{p}d$ cross sections from Particle Data Group, "A Compilation of $\bar{N}N$ and $\bar{N}D$ Reactions," LBL-58 (1972); some points added since original compilation.

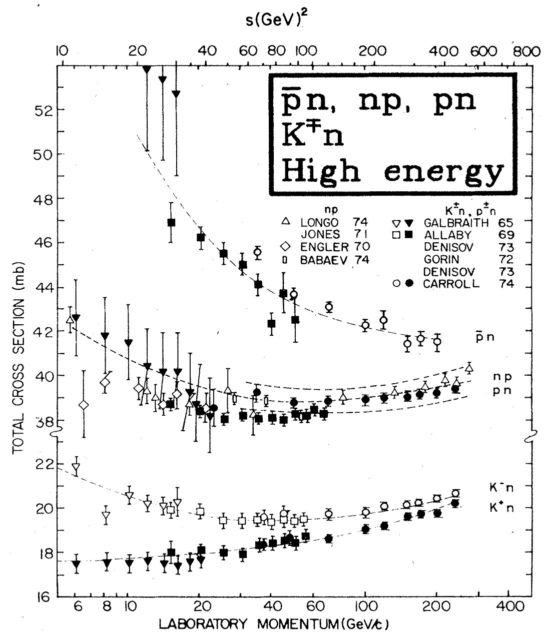
CROSS SECTION PLOTS (Cont'd)



Total and elastic pp cross-section data compiled by U. Amaldi, CERN.



p̄p, pp, π^-p, π^+p, K^-p, and K^+p total cross sections versus $s(\approx 2m_pp_{lab})$, as compiled by U. Amaldi, CERN.



p̄n, np, pn, K^-n, and K^+n total cross sections versus $s(\approx 2m_pp_{lab})$, as compiled by G. Giacomelli, CERN.

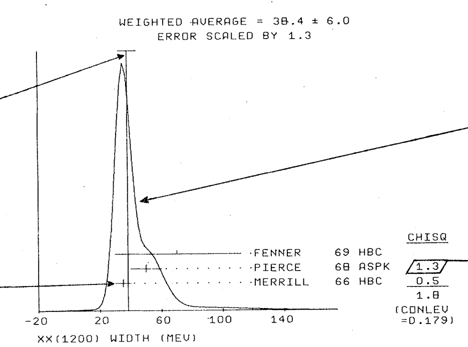
DATA CARD LISTINGS

Illustrative Key

```
                  74  XX MESON (1200,JPG=  -)  I=1
  XX(1200)            ORIGINALLY CALLED XXX
  ------------->      OMITTED FROM TABLE
------ --------- --------- --------- --------- --------- --------- --------

                       74  XX(1200) MASS (MEV)
M            1216.           11.          MERRILL    66 HBC    0 3.2 K-P       7/66
M   L  150  (1192.)          (16.)        LYNCH      67 HBC   +-  2.7 PI-P     6/67
M   L   LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION
M            1198.           10.     7.   PIERCE     68 ASPK  +   2.1 K-P      9/68
M   S       (1208.)                       FENNER     69 HBC    0 4.2 PI+P      9/69
M   S    80 1210.            8.           SMITH      70 MMS   -  3.5 PI-P      2/79*
M   S   SUPERSEDES EARLIER RESULT
M               . . . . . . . . .
M   AVG      1206.9          5.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
------ --------- --------- --------- --------- --------- --------- --------

                       74  XX(1200) WIDTH (MEV)
W             35.            5.           MERRILL    66 HBC    0 3.2 K-P       7/66
W             50.            10.          PIERCE     68 ASPK  +   2.1 K-P      9/68
W             70.            40.          FENNER     69 HBC    0 4.2 PI+P      9/69
W            (60.)           OR LESS      SMITH      70 MMS   -  3.5 PI-P      2/79*
W               . . . . . . . . .
W   AVG       38.4           6.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                             (SEE IDEOGRAM BELOW )
```

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                       74  XX(1200) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1        XX(1200) INTO 3PI                              139+ 139+ 139
P2        XX(1200) INTO K KBAR                           493+ 493
------ --------- --------- --------- --------- --------- --------- --------

                       74  XX(1200) BRANCHING RATIOS

R1        XX(1200) INTO 3PI/TOTAL                          (P1)
R1              .66         .02        MERRILL    66 HBC    0 3.2 K-P        7/66
R1   L         (.68)       (.03)       LYNCH      67 HBC   +-  2.7 PI-P      6/67
R1   L    LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION
R1              . . . . . . . . .
R1   FIT      0.675       0.012   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2        XX(1200) INTO KKBAR/TOTAL                        (P2)
R2              .35         .05        PIERCE     68 ASPK  +   2.1 K-P       9/68
R2              . . . . . . . . .
R2   FIT      0.325       0.012   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R3        XX(1200) INTO KKBAR/3PI                        (P2)/(P1)
R3              .50         .03        FENNER     69 HBC    0 4.2 PI+P       9/69
R3              .41         .04        SMITH      70 MMS   -  3.5 PI-P       2/79*
R3              . . . . . . . . .
R3   AVG      0.468       0.043   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
R3   FIT      0.480       0.026   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

****** ********* ********* ********* ********* ********* ********* ********

                         REFERENCES FOR XX(1200)

MERRILL  66 PRL 16 143       A. MERRILL                   (TORINO+CERN) IJP
LYNCH    67 PR 155 610       B. LYNCH                              (BNL)
PIERCE   68 PL 27B 230       N. PIERCE                             (LRL)
FENNER   69 NC 61B 372       D. FENNER, B. BEANE             (NYSE+AMEX)
SMITH    70 PRL 24 14        J. SMITH                             (SLAC)
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
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- Name of particle as it appears in table.
- Arrow indicates this particle omitted from table.
- Quantity tabulated below.
- Code for quantity tabulated (M=mass, W=width, etc.)
- Symbols used to key together data card and related comments.
- Number of events above background.
- Measured values (parentheses indicate value not used in average).
- ± Error in measured value (– field blank if error symmetric; parentheses on error only indicate data not used in average due to problems with error estimation).
- Average value (and error) of quantity measured.
- Vertical bar indicates average; width of horizontal bar on top is error (scaled) in average.
- Value and error for each experiment.
- Partial decay mode (labeled by P_i).
- Branching ratio (labeled by R_j).
- Value (and error) of quantity measured, as determined from constrained fit (using all measured branching ratios for this particle).
- References listed by year, then author.
- Abbreviated reference form used on data cards above.
- Journal, report, preprint, etc. (see abbreviations on next page).

- Particle name, and quantum numbers (if known).
- Particle code (for internal use only).
- General comments on particle.
- Abbreviated reference for this result; full reference given below.
- Measurement technique (see abbreviations on next page.)
- Charge(s) of particle detected.
- Reaction producing particle, or comments.
- Date this result punched (asterisk indicates result added or changed since previous edition).
- Scale factor > 1 indicates inconsistent data.
- Ideogram to display inconsistent data; curve is sum of Gaussians, one for each experiment (area of Gaussian = 1/error; width of Gaussian = ± error).
- Contribution of experiment to χ^2 (if no entry present, experiment not used in calculating χ^2 or scale factor because of large error).
- Representative masses of decay products (used for calculating last column of Particle Property Tables)
- Branching ratio R_j in terms of partial decay mode fractions P_i above.
- Author(s)
- Quantum number determinations in this reference
- Institution(s) of author(s) (see abbreviations on next page).

Illustrative Key *(cont'd)*

Abbreviations

Journals

APAH	Acta Phys. Acad. Hungarica
ADVP	Advances in Physics
ANP	Annals of Physics
ARNS	Annual Review of Nuclear Science
BAPS	Bulletin of the Amer. Phys. Soc.
CJP	Canadian Journal of Physics
JAP	Journal of Applied Physics
JETP	English Transl. of Soviet Physics JETP
JETPL	Letters of Soviet Physics JETP
JPA	Journal of Physics A
JPG	Journal of Physics G
JPSJ	Journal of the Phys. Soc. of Japan
LNC	Letters to Nuovo Cimento
NC	Nuovo Cimento
NIM	Nuclear Instruments and Methods
NP	Nuclear Physics
PL	Physics Letters
PN	Particles and Nuclei
PPSL	Proc. of the Phys. Soc. of London
PR	Physical Review
PRAM	Pramana
PRL	Physical Review Letters
PRSE	Proc. of the Royal Soc. of Edinburgh
PRSL	Proc. of the Royal Soc. of London
PTP	Progress of Theoretical Physics
RMP	Reviews of Modern Physics
RRP	Revue Romaine de Physique
SJNP	Soviet Journal of Nuclear Physics
SPU	Soviet Physics - Uspekhi
ZNAT	Zeitschrift fur Naturforschung
ZPHY	Zeitschrift fur Physik

Conferences

Conferences are referred to by the location in which they were held (e.g., DUBNA, BOULDER, LUND, etc.).

Measurement Techniques

ASPK	Automatic spark chambers
CC	Cloud chamber
CNTR	Counters
DASP	DESY double-arm spectrometer
DBC	Deuterium bubble chamber
DLCO	SLAC-SPEAR DELCO detector
DPWA	Energy-dependent PWA
ELEC	Electronic combination
EMUL	Emulsions
FBC	Freon bubble chamber
FRAB	ADONE $B\bar{B}$ Group detector
FRAG	ADONE $\gamma\gamma$ Group detector
FRAM	ADONE MEA Group detector
HBC	Hydrogen bubble chamber
HEBC	Helium bubble chamber
HLBC	Heavy liquid bubble chamber
HYBR	Hybrid: BC + electronics
IPWA	Energy-independent PWA
MMS	Missing mass spectrometer
MPWA	Model-dependent PWA
NEUL	Neuland large-angle ν spectrometer
OMEG	CERN OMEGA spectrometer
OSPK	Optical spark chamber
PBC	Propane bubble chamber
PLAS	Plastic detector
PLUT	DESY PLUTO detector
PWA	Partial-wave analysis
RVUE	Review of previous data
SFM	CERN split field magnet
SMAG	SPEAR magnetic detector
SMK2	SLAC Mark II detector
SPEC	Spectrometer
SPRK	Spark chamber
STRC	Streamer chamber
WIRE	Wire chamber
XEBC	Xenon bubble chamber

Institutions

AACH	Technische Univ. Aachen	Aachen, Germany
AARH	Aarhus Univ.	Aarhus, Denmark
ABO	Abo Akademi	Abo, Finland
ADEL	Adelphi Univ.	Garden City, N. Y., USA
AERE	Atomic Energy Res. Estab.	Harwell, Berks., England
AICH	Aichi Educational Univ.	Toyota, Aichi Pref., Japan
ALBA	State Univ. of New York at Albany	Albany, N. Y., USA
ALBE	Alberta Univ., NRC	Edmonton, Canada
AMST	Univ. of Amsterdam	Amsterdam, Netherlands
ANKA	Middle East Technical Univ.	Ankara, Turkey
ANL	Argonne National Lab.	Argonne, Ill., USA
ARIZ	Univ. of Arizona	Tucson, Ariz., USA
ATEN	Nuclear Res. Centre Demokritos	Athens, Greece
ATHU	Univ. of Athens	Athens, Greece
AUCK	Univ. of Auckland	Auckland, New Zealand
BARC	Univ. de Barcelona	Barcelona, Spain
BARI	Univ. di Bari	Bari, Italy
BART	Bartol Research Foundation	Swarthmore, Pa., USA
BASL	Basel Univ.	Basel, Switzerland
BEDF	Bedford College	London, England
BELG	Inst. Interuniv. des Sci. Nuc.	Bruxelles, Belgium
BELL	Bell Labs.	Murray Hill, N. J., USA
BERG	Univ. of Bergen	Bergen, Norway
BERL	Inst. Hochenergiephys. DAW	Zeuthen/Berlin, DDR
BERN	Univ. Bern	Bern, Switzerland
BGNA	Univ. di Bologna	Bologna, Italy
BING	State Univ. of New York at Binghamton	Binghamton, N. Y., USA
BIRM	Birmingham Univ.	Birmingham, England
BNL	Brookhaven National Lab.	Upton, L.I., N. Y., USA
BOHR	Niels Bohr Inst.	Copenhagen, Denmark
BOIS	Boise State Univ.	Boise, Idaho, USA
BONN	Univ. Bonn	Bonn, Germany
BORD	Univ. de Bordeaux	Bordeaux, France
BOST	Boston Univ.	Boston, Mass., USA
BRAN	Brandeis Univ.	Waltham, Mass., USA
BRCO	Univ. of British Columbia	Vancouver, Canada
BRIS	H. H. Wills Phys. Lab., U. of Bristol	Bristol, England
BROW	Brown Univ.	Providence, R. I., USA
BRUX	Univ. Libre de Bruxelles	Bruxelles, Belgium
BUCH	Bucharest State Univ.	Bucharest, Romania
BUDA	Central Research Inst. of Physics	Budapest, Hungary
BUFF	State Univ. of New York at Buffalo	Buffalo, N. Y., USA
CAEN	Lab. de Phys. Corpusculaire	Caen, France
CAMB	Cambridge Univ.	Cambridge, England
CANB	Australian National Univ.	Canberra, Australia
CARL	Carleton Univ.	Ottawa, Canada
CARN	Carnegie-Mellon Univ.	Pittsburgh, Pa., USA
CASE	Case Western Reserve Univ.	Cleveland, Ohio, USA
CATH	Catholic Univ. of America	Washington, D. C., USA
CAVE	Cavendish Lab., Cambridge Univ.	Cambridge, England
CCAC	Community College of Allegheny County	Pittsburgh, Penn., USA
CDEF	College de France	Paris, France
CEA	Cambridge Electron Accel.	Cambridge, Mass., USA
CENG	CEN, Grenoble	Grenoble, France
CERN	European Org. for Nuclear Research	Geneva, Switzerland
CHIC	Univ. of Chicago	Chicago, Ill., USA
CINC	Univ. of Cincinnati	Cincinnati, Ohio, USA
CIT	Calif. Inst. of Technology	Pasadena, Calif., USA
CNRC	Canadian National Research Council	Ottawa, Canada
COLO	Univ. of Colorado	Boulder, Colo., USA
COLU	Columbia Univ.	New York, N. Y., USA
CORN	Cornell Univ.	Ithaca, N. Y., USA
COSU	Colorado State Univ.	Fort Collins, Colo., USA
CRAC	Inst. for Nuclear Research	Cracow, Poland
CUNY	City Univ. of New York	New York, N. Y., USA
CURI	Laboratoire Joliot-Curie	Paris, France
DARE	Daresbury Nuclear Physics Lab.	Daresbury, England
DART	Dartmouth College	Hanover, N. H., USA
DESY	Deutsches Elektronen-Synchrotron	Hamburg, Germany
DORT	Univ. Dortmund	Dortmund, Germany
DUKE	Duke Univ.	Durham, N. C., USA
DURH	Univ. of Durham	Durham, England
DUUC	University College	Dublin, Ireland
EDIN	Univ. of Edinburgh	Edinburgh, Scotland
EFI	Enrico Fermi Inst. for Nucl. Studies	Chicago, Ill., USA
EPOL	Ecole Polytechnique	Paris, France
ETH	Swiss Federal Inst. of Technology	Zurich, Switzerland
FIRZ	Univ. di Firenze	Firenze, Italy
FISK	Fisk Univ.	Nashville, Tenn., USA
FLOR	Univ. of Florida	Gainsville, Fla., USA
FNAL	Fermi National Accelerator Lab.	Batavia, Ill., USA
FOM	Found. for Fundamental Res. on Matter	Utrecht, Netherlands
FRAS	Lab. Nazionali del C.N.E.N.	Frascati, Italy
FREI	Univ. of Freiburg	Freiburg, Germany
FSU	Florida State Univ.	Tallahassee, Fla., USA
GENO	Univ. di Genova	Genova, Italy
GESC	General Electric Res. and Dev. Center	Schenectady, N. Y., USA
GEVA	Univ. de Geneve	Geneva, Switzerland
GLAS	Univ. of Glasgow	Glasgow, Scotland
GRAZ	Univ. Graz	Graz, Austria
GREN	Inst. des Sci. Nuc., Univ. de Grenoble	Grenoble, France
GSCO	Geological Survey of Canada	Ottawa, Canada
HAIF	Technion - Israel Inst. of Technology	Haifa, Israel
HAMB	Univ. Hamburg	Hamburg, Germany
HARV	Harvard Univ.	Cambridge, Mass., USA
HAWA	Univ. of Hawaii	Honolulu, Hawaii, USA
HEID	Univ. Heidelberg	Heidelberg, Germany
HELS	Helsingin Yliopisto	Helsinki, Finland
HIRO	Hiroshima Univ.	Hiroshima, Japan
HOUS	Univ. of Houston	Houston, Texas, USA
IBM	International Business Machines	Palo Alto, Calif., USA
IIT	Illinois Inst. of Tech.	Chicago, Ill., USA
ILL	Univ. of Illinois	Urbana, Ill., USA
ILLC	Univ. of Illinois at Chicago	Chicago, Ill., USA
ILLG	Inst. Laue-Langevin	Grenoble, France
IND	Univ. of Indiana	Bloomington, Ind., USA
INNS	Phys. Inst., Univ. Innsbruck	Innsbruck, Austria
IOWA	Univ. of Iowa	Iowa City, Iowa, USA

Illustrative Key *(cont'd)*

Abbreviations *(cont'd)*

Institutions (cont'd)

IPN	Inst. de Phys. Nucleaire	Orsay, France
IPNP	Inst. de Physique Nucleaire	Paris, France
IPPC	Inst. for Particle Physics of Canada	Montreal, Canada
IRAD	Inst. du Radium	Paris, France
ISU	Iowa State Univ.	Ames, Iowa, USA
ITEP	Inst. for Teor. and Exp. Phys.	Moscow, USSR
IUPU	Indiana U. - Purdue U. at Indianapolis	Indianapolis, Ind., USA
JAGL	Jagellonian Univ.	Cracow, Poland
JHU	Johns Hopkins Univ.	Baltimore, Md., USA
JINR	Joint Inst. for Nucl. Research	Dubna, USSR
KANS	Univ. of Kansas	Lawrence, Kansas, USA
KARL	Univ. Karlsruhe	Karlsruhe, Germany
KEK	Nat. Lab for High Energy Phys., Japan	Tsukuba-gun, Japan
KENT	Kent Univ. at Cantebury, Kent	Cantebury, England
KEYN	Open Univ.	Milton Keynes, England
KIAE	Kurchatov Inst. of Atomic Energy	Moscow, USSR
KIEV	Physical-Technical Inst.	Kiev, USSR
KINK	Kinki Univ.	Osaka, Japan
KNTY	Univ. of Kentucky	Lexington, Ky., USA
KONA	Konan Univ.	Kobe, Japan
KONS	B. P. Konstantinov Inst. of Nucl. Phys.	USSR
LALO	Linear Accelerator Lab, Orsay	Orsay, France
LANC	Lancaster Univ.	Lancaster, England
LAPP	Lapp Univ.	Annecy, France
LASL	U. C. Los Alamos Scientific Lab.	Los Alamos, N. M., USA
LAUS	Univ. of Lausanne	Lausanne, Switzerland
LBL	U. C. Lawrence Berkeley Lab.	Berkeley, Calif., USA
LCGT	Lab. di Cosmo-Geofisica del CNR	Torino, Italy
LEBD	Lebedev Physics Inst.	Moscow, USSR
LEED	Univ. of Leeds	Leeds, England
LEHI	Lehigh Univ.	Bethlehem, Pa., USA
LEID	Inst. Lorentz	Leiden, Netherlands
LENI	Inst. of Nucl. Phys., USSR Acad. Sci.	Leningrad, USSR
LIBH	Lab. Interuniv. Belge High Eng.	Bruxelles, Belgium
LINZ	Linz Inst. fur Physik, Kepler Hoch.	Linz, Austria
LIVP	Liverpool Univ.	Liverpool, England
LLL	Lawrence Livermore Lab.	Livermore, Calif., USA
LOIC	Imperial Col. of Sci. and Tech.	London, England
LOQM	Queen Mary College	London, England
LOUC	University College	London, England
LOWC	Westfield College	London, England
LPNP	Lab. de Phys. Nucl. et Hautes Energies	Paris, France
LPTP	Lab. de Phys. Theor. et Hautes Energies	Paris, France
LRL	U. C. Lawrence Berkeley Lab.	Berkeley, Calif., USA
LSU	Louisiana State Univ.	Baton Rouge, La., USA
LUND	Univ. I Lund	Lund, Sweden
MADR	Junta de Energia Nuclear	Madrid, Spain
MADU	Univ. Autonome de Madrid	Madrid, Spain
MANH	Manhattan College	New York, N. Y., USA
MANI	Univ. of Manitoba	Winnipeg, Canada
MANZ	Univ. Mainz	Mainz, Germany
MASA	Univ. of Massachusetts	Amherst, Mass., USA
MASB	Univ. of Massachusetts	Boston, Mass., USA
MCGI	McGill Univ.	Montreal, Canada
MCHS	Univ. Manchester	Manchester, England
MELB	Univ. of Melbourne	Parkville, Australia
MHCO	Mount Holyoke College	South Hadley, Mass., USA
MICH	Univ. of Michigan	Ann Arbor, Mich., USA
MILA	Univ. di Milano	Milano, Italy
MINN	Univ. of Minnesota	Minneapolis, Minn., USA
MIOH	Miami Univ.	Oxford, Ohio, USA
MIT	Massachusetts Inst. of Technology	Cambridge, Mass., USA
MODE	Ist. di Fisica dell Univ.	Modena, Italy
MONP	Univ. de Montpellier	Montpellier, France
MONS	Univ. de l'Etat, Mons	Mons, Belgium
MONT	Univ. de Montreal	Montreal, Canada
MOSU	Moscow State Univ.	Moscow, USSR
MPEI	Moscow Phys. Eng. Inst.	Moscow, USSR
MPIH	Max Planck Inst. fur Phys.-Astrophys.	Heidelberg, Germany
MPIM	Max Planck Inst. fur Phys.-Astrophys.	Munich, Germany
MSNA	Ist. di Fisica dell Univ.	Messina, Italy
MSU	Michigan State Univ.	East Lansing, Mich., USA
MTHO	Mt. Holyoke College	South Hadley, Mass., USA
MULH	Centre Univ. du Haut-Rhin	Mulhouse, France
MUNC	Univ. of Munich	Munich, Germany
MURA	Midwestern Univ. Research Assoc.	Stroughton, Wisc., USA
NAGO	Nagoya Univ.	Nagoya, Japan
NAPL	Univ. di Napoli	Napoli, Italy
NASA	NASA, Goddard Space Flight Center	Greenbelt, Md., USA
NDAM	Univ. of Notre Dame	Notre Dame, Ind., USA
NEAS	Northeastern Univ.	Boston, Mass., USA
NEUC	Univ. de Neuchatel	Neuchatel, Switzerland
NEVI	Nevis Lab.	Irvington-on-Hudson, N. Y., USA
NIJM	R. K. Univ. Nijmegen	Nijmegen, Netherlands
NIU	Northern Illinois Univ.	De Kalb, Ill., USA
NORD	Nordisk Inst. for Teor. Atomfys.	Copenhagen, Denmark
NOVO	Inst. of Nucl. Phys.	Novosibirsk, USSR
NPOL	Northern Polytechnic	London, England
NRL	Naval Research Laboratory	Washington, D.c., USA
NWES	Northwestern Univ.	Evanston, Ill., USA
NYU	New York Univ.	New York, N. Y., USA
OHIO	Ohio Univ.	Athens, Ohio, USA
OREG	Univ. of Oregon	Eugene, Ore., USA
ORNL	Oak Ridge National Lab.	Oak Ridge, Tenn., USA
ORSA	Univ. de Paris, Fac. des Sci.	Orsay, France
OSAK	Osaka Univ.	Osaka, Japan
OSKC	Osaka City Univ.	Osaka, Japan
OSLO	Oslo Univ.	Oslo, Norway
OSU	Ohio State Univ.	Columbus, Ohio, USA
OTTA	Univ. of Ottawa	Ottawa, Canada
OXF	Oxford Univ.	Oxford, England
PADO	Univ. di Padova	Padova, Italy
PATR	Univ. of Patras	Patras, Greece
PAVI	Univ. di Pavia	Pavia, Italy
PENN	Univ. of Pennsylvania	Philadelphia, Pa., USA
PISA	Univ. di Pisa	Pisa, Italy
PITT	Univ. of Pittsburgh	Pittsburgh, Pa., USA
PPA	Princeton-Penn. Proton Accel.	Princeton, N. J., USA
PRAG	Inst. of Physics, CSAV	Prague, Czechoslovakia
PRIN	Princeton Univ.	Princeton, N. J., USA
PSLL	Physical Science Lab.	Las Cruces, N. M., USA
PURD	Purdue Univ.	Lafayette, Ind., USA
REHO	Weizmann Inst. of Sci.	Rehovoth, Israel
RHEL	Rutherford High Energy Lab.	Chilton, Did., Berks., England
RICE	William Marsh Rice Univ.	Houston, Texas, USA
RISO	Research Estab. Riso	Roskilde, Denmark
RL	Rutherford Lab. (formerly RHEL)	Chilton, Did., Berks., England
RMCS	Royal Military College of Science	Shrivenham, England
ROCH	Univ. of Rochester	Rochester, N. Y., USA
ROCK	Rockefeller Univ.	New York, N. Y., USA
ROMA	Univ. di Roma	Roma, Italy
ROSE	Rose Polytechnic Inst.	Terre Haute, Ind., USA
RUTG	Rutgers Univ.	New Brunswick, N. J., USA
SACL	Cntr. d'Etudes Nucl. Saclay	Gif-sur-Yvette, France
SAGA	Saga Univ.	Saga, Japan
SANI	Ist. Superiore di Sanita	Roma, Italy
SBER	San Bernardino State College	San Bernardino, Calif., USA
SEAT	Seattle Pacific College	Seattle, Wash., USA
SEIB	Research Center Seibersdorf	Vienna, Austria
SERP	Inst. of High Energy Physics	Serpukov, USSR
SETO	Seton Hall Univ.	South Orange, N. J., USA
SFLA	Univ. of South Florida	Tampa, Fla., USA
SHEF	Univ. of Sheffield	Sheffield, England
SHMP	Univ. of Southampton	Southampton, England
SIBE	Inst. of Nucl. Phys., USSR Acad. Sci.	Siberia, USSR
SIEG	Gesamthochschule Siegen	Huttental, Germany
SIN	Swiss Inst. of Nuclear Research	Villigen, Switzerland
SLAC	Stanford Linear Accel. Center	Stanford, Calif., USA
SMAS	Southeastern Massachusetts Univ.	North Dartmouth, Mass., USA
SOFI	Bulgarian Acad. of Sci.	Sofia, Bulgaria
STAN	Stanford Univ.	Stanford, Calif., USA
STEV	Stevens Inst. of Tech.	Hoboken, N. J., USA
STLO	St. Louis Univ.	St. Louis, Mo., USA
STOH	Stockholm Univ.	Stockholm, Sweden
STON	State Univ. of New York at Stonybrook	Stonybrook, L.i., N. Y., USA
STRB	Centre des Res. Nucleaires	Strasbourg, France
SURR	Univ. of Surrey	Surrey, England
SUSS	Univ. of Sussex	Falmer, Brighton, England
SYRA	Syracuse Univ.	Syracuse, N. Y., USA
TAMU	Texas A and M Univ.	College Station, Texas, USA
TATA	Tata Inst. of Fundamental Research	Bombay, India
TELA	Univ. of Tel-Aviv	Tel-Aviv, Israel
TEMP	Temple Univ.	Philadelphia, Pa., USA
TENN	Univ. of Tennessee	Knoxville, Tenn., USA
TEXA	Univ. of Texas	Austin, Texas, USA
TMSK	Nucl. Phys. Inst., Tomsk Polytech Inst.	Tomsk, USSR
TNTO	Univ. of Toronto	Toronto, Canada
TOHO	Tohoku Univ.	Sendai, Japan
TOKY	Univ. of Tokyo	Tokyo, Japan
TORI	Univ. di Torino	Torino, Italy
TRIU	TRIUMF, Univ. of British Columbia	Vancouver, Canada
TRST	Univ. di Trieste	Trieste, Italy
TUFT	Tufts Univ.	Medford, Mass., USA
TWAS	Waseda Univ.	Tokyo, Japan
UBEL	Univ. of Belgrade	Belgrade, Yugoslavia
UCB	Univ. of Calif. at Berkeley	Berkeley, Calif., USA
UCD	Univ. of Calif. at Davis	Davis, Calif., USA
UCI	Univ. of Calif. at Irvine	Irvine, Calif., USA
UCLA	Univ. of Calif. at Los Angeles	Los Angeles, Calif., USA
UCND	Union Carbide Nuclear Division	Oak Ridge, Tenn., USA
UCR	Univ. of Calif. at Riverside	Riverside, Calif., USA
UCSB	Univ. of Calif. at Santa Barbara	Santa Barbara, Calif., USA
UCSC	Univ. of Calif. at Santa Cruz	Santa Cruz, Calif., USA
UCSD	Univ. of Calif. at San Diego	La Jolla, Calif., USA
UMD	Univ. of Maryland	College Park, Md., USA
UNCS	Union College	Schenectady, N. Y., USA
UNH	Univ. of New Hampshire	Durham, N. H., USA
UPNJ	Upsala College	East Orange, N. J., USA
UPPS	Gustaf Werner Inst.	Uppsala, Sweden
UTAH	Univ. of Utah	Salt Lake City, Utah, USA
UTRE	Univ. of Utrecht	Utrecht, Netherlands
VAND	Vanderbilt Univ.	Nashville, Tenn., USA
VICT	Univ. of Victoria	Victoria, Canada
VIEN	Inst. for High Energy Physics, A. A. S.	Vienna, Austria
VIRG	Univ. of Virginia	Charlottesville, Va., USA
VPI	Virginia Polytechnic Inst.	Blacksburg, Va., USA
WARS	Univ. of Warsaw	Warsaw, Poland
WASH	Univ. of Washington	Seattle, Wash., USA
WIEN	Univ. Wien	Wien, Austria
WILL	College of William and Mary	Williamsburg, Va., USA
WISC	Univ. of Wisconsin	Madison, Wisc., USA
WOOD	Woodstock College	Woodstock, Md., USA
WUPG	Gesamthochschule Wuppertal	Wuppertal, Germany
WUPP	Univ. Wuppertal	Wuppertal, Germany
WUSL	Washington Univ.	St. Louis, Mo., USA
WYOM	Univ. of Wyoming	Laramie, Wyoming, USA
YALE	Yale Univ.	New Haven, Conn., USA
YOKO	Yokohama Univ.	Yokohama, Japan
ZEEM	Zeeman Lab., Univ. of Amsterdam	Amsterdam, Netherlands
ZURI	Univ. Zurich	Zurich, Switzerland

Data Card Listings

For notation, see key at front of Listings.

Stable Particles

γ, ν

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****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
[γ]                  0  GAMMA(0,J=1)
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                     0  GAMMA MASS (IN UNITS OF 10**-21 MEV)

M   P        (6.)   OR LESS              PATEL     65        SATELLITE DATA   10/69
M             6.    OR LESS              GINTSBURG 64        SATELLITE DATA   .10/69
M             2.3   OR LESS              GOLDHABER 68        SATELLITE DATA   10/69
M   F        (0.06) OR LESS              FRANKEN   71        LOW FREQ RES CIR  3/72
M            10.    OR LESS              WILLIAMS  71 CNTR   TESTS GAUSS LAW   3/71
M          (4.E-13)MEV OR LESS           LOWENTHAL 73        GENL RELATIVITY   8/77
M             0.73  OR LESS              HOLLWEG   74        ALFVEN WAVES      7/74
M             0.6   OR LESS   CL=.997    DAVIS     75        JUPITER MAGFIELD  1/78
M   F   INVALID MEASUREMENT.   SEE CRITICISM IN KROLL 71 AND GOLDHABER 71.     3/78

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                          REFERENCES FOR GAMMA

GINTSBUR 64 SOV. ASTR.AJ7 536 M. A. GINTSBURG                  (ACAD SCI,USSR)
PATEL    65 PL     14  105    V. L. PATEL                            (DURHAM)
GOLDHABE 68 PRL    21  567    A. GOLDHABER,M. NIETO            (STONY BROOK)
FRANKEN  71 PRL 26 115        P A FRANKEN, G W AMPULSKI                (MICH)
WILLIAMS 71 PRL 26 721        +FALLER,HILL                         (WESLEYAN)

LOWENTHA 73 PR D8 2349        D.D.LOWENTHAL                             (UCI)
HOLLWEG  74 PRL 32 961        J V HOLLWEG  (NATL CENTER FOR ATMOS RESRCH)
DAVIS    75 PRL 35 1402       +GOLDHABER,NIETO                (CIT+STON+LASL)

                          PAPERS NOT REFERRED TO IN DATA CARDS

GOLDHABE 71 RMP 43 277        A S GOLDHABER, M M NIETO  (STON+BOHR+UCSB)
KROLL    71 PRL 26 1395       N M KROLL                                (SLAC)
BYRNE    77 AST.SP.SCI.46 115 J.C.BYRNE                                (LOIC)

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Note on Neutrino Mass Limits

(by R. Shrock, State Univ. of New York, Stonybrook)

In the conventional case where all neutrinos are assumed to be massless and hence degenerate, it is possible to define the neutrino weak-gauge-group eigenstates ν_e, ν_μ, and ν_τ (i.e., the states which couple with unit strength to e, μ, and τ, respectively) to be simultaneously mass eigenstates. However, in the general case of massive (nondegenerate) neutrinos, the gauge-group eigenstates have no well-defined masses, but instead are linear combinations of mass eigenstates, which may be labeled ν_1, ν_2, and ν_3. In the standard $SU(2)_L \otimes U(1)$ electroweak theory,[1] the mixing of the left-handed components of the mass eigenstates to form gauge-group eigenstates is specified[2] by a $3 \otimes 3$ unitary matrix U:

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix}_L = U \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}_L .$$

(The right-handed components ν_{iR} are singlets.) The lepton mixing matrix U depends on four real parameters, of which three are CP-conserving rotation angles, and the remaining one is a CP-violating phase. It is easy to generalize these remarks to the case of $n > 3$ neutrino species. One should note, however, that there are indications from astrophysics[3] that n may not be larger than 3.

Thus, in the general case of n neutrino species, decays such as $^3H \rightarrow {}^3He + e^- + \bar{\nu}_e$ and $\pi^+ \rightarrow \mu^+ + \nu_\mu$, which have been used to set the best upper bounds on the respective neutrino masses,[4,5] really consist of incoherent sums of the separate decay modes $^3H \rightarrow {}^3He + e^- + \nu_i$ and $\pi^+ \rightarrow \mu^+ + \nu_j$, where the ν_i, ν_j are mass eigenstates, and $i = 1,\ldots,k \leq n$, $j = 1,\ldots,k' \leq n$, with ν_k and $\nu_{k'}$ being the heaviest such states allowed by phase space in these two respective decays. The coupling strength for the i^{th} mode is given for the two decays by the factors $|U_{1i}|^2 \equiv |U_{ei}|^2$ and $|U_{2i}|^2 \equiv |U_{\mu i}|^2$. There are, in addition, certain kinematic factors depending on $m(\nu_i)$ which enter in determining the branching ratio for the i^{th} decay mode. Since the off-diagonal elements of the lepton mixing matrix U are constrained to be rather small, the dominant decays are the ones with coupling strength $|U_{ij}|^2$, where i=j, i.e., $^3H \rightarrow {}^3He + e + \nu_1$ and $\pi^+ \rightarrow \mu^+ + \nu_2$.

It follows that: (1) the old neutrino mass limits quoted in the literature for "$m(\nu_e)$", "$m(\nu_\mu)$", and "$m(\nu_\tau)$" are meaningful only as limits on $m(\nu_i)$, i = 1, 2, and 3, respectively; (2) a neutrino mass limit cannot be given in isolation — it always contains some implicit dependence on the relevant lepton mixing angles. Fortunately, however, this dependence is relatively unimportant for the dominantly coupled decay modes, i.e., $e\nu_1$, $\mu\nu_2$, and $\tau\nu_3$, since $|U_{ij}|^2$ is close to unity for i=j. Since these decay modes were the ones responsible for the mass limits given previously, the latter can be reinterpreted without significant change or complication as proper limits on $m(\nu_i)$, i = 1, 2, and 3. This has been done in the Table.

Further neutrino mass limits arising from subdominantly coupled decay modes and other phenomena, such as neutrino oscillations, which involve U_{ij} with $i \neq j$, are dependent upon the unknown lepton mixing angles, and hence we shall not consider them in the present edition.

References

1. S. Weinberg, Phys. Rev. Lett. 19, 1264 (1967); A. Salam, in Elementary Particle Theory: Relativistic Groups and Analyticity, edited by N. Svartholm (Alqvist & Wiksell, Stockholm,

Stable Particles

ν, ν_e, e, ν_μ

Data Card Listings

For notation, see key at front of Listings.

1968), p.367. See also S. Glashow, Nucl. Phys. 22, 579 (1961); S. Glashow, J. Iliopoulos, and L. Maiani, Phys. Rev. D2, 1285 (1970); and, for the n=3 case, M. Kobayashi and T. Maskawa, Prog. Theor. Phys. 49, 652 (1973).

2. See, e.g., B. W. Lee and R. E. Shrock, Phys. Rev. D16, 1444 (1977).
3. J. Yang et al., Astrophys. J. 227, 697 (1979); see also footnote 4 in G. Steigman et al., Phys. Rev. Lett. 43, 239 (1979).
4. K. Berkvist, Nucl. Phys. B39, 317 (1972).
5. M. Daum et al., Phys. Rev. D20, 2692 (1979).

ν_e

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                        1   E-NEUTRINO(0,J=1/2)
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                        1   E-NEUTRINO MASS (KEV)

M          (0.25) OR LESS              LANGER    52 CNTR ANTI-NEUT.(TRITIUM)
M          (0.50) OR LESS              HAMILTON  53 CNTR ANTI-NEUT.(TRITIUM).11/73
M          (0.55)   (0.28)             FRIEDMAN  58 CNTR ANTI-NEUT.(TRITIUM)
M           4.1    OR LESS  CL=.67     BECK      68 CNTR NEUTRINO(SODIUM 22) 11/73
M    D      0.5    OR LESS  CL=.90     DARIS     69 CNTR ANTI-NEUT.(TRITIUM) 11/73
M           0.32   OR LESS  CL=.90     SALGO     69 CNTR ANTI-NEUT.(TRITIUM) 11/73
M           0.06   OR LESS  CL=.90     BERGKVIS  72 CNT  ANTI-NEUT.(TRITIUM) 11/73
M          (0.008)OR LESS              COWSIK    72 THEOR.LIM.FROM COSMOLOGY  3/74
M           0.086 OR LESS   CL=.90     RODE      72 CNTR ANTI-NEUT.(TRITIUM) 11/73
M    D    DARIS 69 VALUE .075KEV(CL=.67) DISAGREES WITH FIG.6.  WE USE FIG.6. 11/73

M    C       450.     OR LESS  CL=.90   CLARK     74 ASPK KE3 DECAY          11/75
M    C    LOWEST LIMIT FROM STRANGENESS CHANGING DECAY.                      11/75
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                        1   (E-NEUTRINO) - (E-ANTINEUTRINO) MASS DIFF. (KEV)

DM           450.     OR LESS  CL=.90   CLARK     74 ASPK KE3 DECAY          11/75
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                        1   E-NEUTRINO MEAN LIFE/MASS   (UNITS SEC/EV)

T     R      3. E 2   OR MORE           REINES    74 CNTR    ANTI-NEUTRINO    3/78
T           STABLE                      FALK      78         ASTROPHYSICS    12/79*
T     R   REINES 74 LOOKED FOR E-ANTINEUTRINO OF NON-ZERO MASS DECAYING TO    3/78
T     R   A NEUTRAL OF LESSER MASS + GAMMA.  USED LIQUID SCINT. DETECTOR NEAR 3/78
T     R   FISSION REACTOR.  FINDS LAB LIFETIME 6.E7 SEC OR MORE.  ABOVE VALUE 3/78
T     R   OF MEAN LIFE/MASS ASSUMES AVG. EFFECTIVE NEUTRINO ENERGY OF 0.2MEV. 3/78
****** ********* ********* ********* ********* ********* ********* ********

                              REFERENCES FOR E-NEUTRINO

LANGER   52 PR  88  689         L M LANGER,R J D MOFFAT              (INDIANA)
HAMILTON 53 PR  92  1521        D HAMILTON,W P ALFORD,L GROSS      (PRINCETON)
FRIEDMAN 58 PR 109  2214        LEWIS FRIEDMAN,LINCOLN G SMITH           (BNL)
BECK     68 ZPHY 216 229        E BECK,H DANIEL                         (MPIH)
DARIS    69 NP A138 545         R DARIS,C ST-PIERRE            (LAVAL-QUEBEC)
SALGO    69 NP A138 417         R C SALGO,H H STAUB                   (ZURICH)

BERGKVIS 72 NP B39 317          KARL-ERIK BERGKVIST           (UNIV STOCKHOLM)
COWSIK   72 PRL 29 669          R COWSIK,J MC CLELLAND                   (UCB)
RODE     72 LNC 5 139           B RODE,H DANIEL                  (MUNICH+MPIH)
CLARK    74 PR D9 533           +ELIOFF,FRISCH,JOHNSON,KERTH,SHEN+       (LBL)
REINES   74 PRL 32 180          +SOBEL,GURR                              (UCI)
   ALSO  78  PRIVATE COMM.      V. BARNES                               (PURD)

FALK     78 PL 79B 511          S. FALK, D. SCHRAMM                      (EFI)
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e

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                        3   ELECTRON(0.5,J=1/2)
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                        3   ELECTRON MASS (MEV)

M         (.511006)(.00002)          COHEN     65 RVUE
M         (.5110041(.0000016)        TAYLOR    69 RVUE    USING NEW E/H       7/70
M          .5110034 .0000014         COHEN     73 RVUE                        3/74
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                        3   ELECTRON MEAN LIFE (UNITS 10**21 YR)

T              2.0    OR MORE            MOE       65 CNTR                     6/66
T    S         5.3    OR MORE            STEINBERG 75 CNTR                     2/76
T           (350.)    OR MORE  CL=.68    KOVALCHUK 79 CNTR     E- -->NEU GAMMA 1/80*
T    S    STEINBERG 75 SENSITIVE TO ALL DECAY MODES IN WHICH DECAY PARTICLES   2/76
T    S    ESCAPE FROM DETECTOR WITHOUT DEPOSITING ENERGY. TEST OF CHARGE       2/76
T    S    CONSERVATION.                                                        2/76
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                        3   ELECTRON MAGNETIC MOMENT(E/2ME)

MM        SEE RICH 72 FOR A REVIEW OF THEORY AND EXPERIMENTS.                  3/74
MM          (1.0011609)     +-(24)*10**-7 SCHUPP    61 CNTR  -
MM          (1.001159622) +-(27)*10**-9 WILKINSON 63 CNTR -                    8/66
MM          (1.001168)      +-(22)*10**-6 RICH      66 CNTR +   POSITRON       8/66
MM R        (1.001159557) +-(30)*10**-9 RICH      68 CNTR -                    6/68
MM          (1.0011596389)+-(31)*10**-10TAYLOR    69 RVUE                    . 2/71
MM          (1.001159644) +-(7)* 10**-9 WESLEY    70 CNTR                      6/70
MM          (1.0011596577)+-(35)*10**-10WESLEY    71 CNTR -                    2/72
MM          (1.0011603)     +-(12)*10**-7 GILLELAND 72 CNTR +                  2/72
MM          (1.0011596567)+-(35)*10**-10COHEN     73 RVUE                      3/74
MM          (1.001159667) +-(24)*10**-9 WALLS     73 CNTR -   BOLOMETRIC TECHN 11/77
MM           1.0011596524l+-(20)*10**-11VANDYCK   77 CNTR     SINGLE ELECTRON  12/77
MM R      RICH 68 IS REEVALUATION OF WILKINSON 63.

DMM      (E+ ANOMALOUS MAG MOM)- (E- ANOMALOUS MAG MOM)/AVG  UNITS 10**-5
DMM            1.0    OR LESS  CL=.95    SEREDNYAK 77 CNTR                     6/77
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                        3   ELECTRON ELECTRIC DIPOLE MOMENT(UNITS 10**-23 E-CM)

                    TEST OF P OR T VIOLATION IN THE EM INTERACTION

EDM            (0.3)  OR LESS  CL=.90    WEISSKOPF 68 MRS                     12/79*
EDM             8.1       11.6           VASILEV   78                         12/79*
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                              REFERENCES FOR ELECTRON

SCHUPP   61 PR  121   1         A A SCHUPP,R W PIDD,H R CRANE            (MICH)
WILKINSO 63 PR 130 852          D T WILKINSON,H R CRANE                  (MICH)
COHEN    65 RMP 37 537          COHEN,DUMOND  (N.A.AVIATION SCI.CENTER+CIT)
MOE      65 PR 140 B 992        M K MOE,F REINES       (CASE INST TECHNOLOGY)

RICH     66 PRL  17  271        A RICH, H R CRANE                        (MICH)
RICH     68 PRL 20 967          A RICH                                   (MICH)
WEISSKOP 68 PRL 21 1645         WEISSKOPF,CARRICO,GOULD,LIPWORTH+        (BRAN)
TAYLOR   69 RMP 41 375          +PARKER,LANGENBERG               (PRIN+UCI+PENN)

WESLEY   70 PRL 24 1320         J C WESLEY,A.RICH                        (MICH)
WESLEY   71 PR A4 1341          J C WESLEY,A RICH                        (MICH)
GILLELAN 72 PR A5 38            J GILLELAND,A RICH                       (MICH)
RICH     72 RMP 44 250          A RICH,J C WESLEY                        (MICH)

COHEN    73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
WALLS    73 PRL 31 975          F.L.WALLS,T.S.STEIN                      (WASH)
STEINBER 75 PR D12 2582         STEINBERG,KWIATKOWSKI,MAENHAUT,WALL       (UMD)
SEREDNYA 77 PL 66B 102          SEREDNYAKOV,SIDOROV,SKRINSKY+            (NOVO)
VANDYCK  77 PRL 38 310          +SCHWINBERG,DEHMELT                      (WASH)

VASILEV  78 JETP 47 243         +KOLYCHEVA                               (JINR)
KOVALCHU 79 JETPL 29 145        KOVALCHUK+      (NUCLEAR RESEARCH INST-USSR)
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ν_μ

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                        2   MU-NEUTRINO(0,J=1/2)
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                        2   MU-NEUTRINO MASS (MEV)

M             3.5    OR LESS              BARKAS    56 EMUL
M             4.0    OR LESS              DUDZIAK   59 CNTR
M             3.6    OR LESS              FEINBERG  63 RVUE                   7/66
M             3.0    OR LESS              ALLCOCK   65 RVUE                   7/66
M             2.5    OR LESS              BARDON    65 ASPK
M             2.8    OR LESS   CL=.90     SHAFER    65 CNTR                   5/71
M             1.6    OR LESS   CL=.90     BOOTH     67 CNTR                   3/68
M             2.2    OR LESS   CL=.90     HYMAN     67 HEBC    0. K- HE      11/67
M    B M     (1.2)   OR LESS   CL=.90     BACKENSTO 71 CNTR    M**2=-1.28+-1.24 10/71
M    S        1.15   OR LESS   CL=.90     SHRUM     71 CNTR    M**2=-1.55+-1.14 12/71
M           (8 EV)   OR LESS              COWSIK    72 THEOR.LIM.FROM COSMOLOGY  3/74
M    B M      1.15   OR LESS   CL=.90     BACKENSTO 73 CNTR    M**2=-0.29+-0.90  1/73
M             0.65   OR LESS   CL=.90     CLARK     74 ASPK    KMU3 DECAY        7/74
M     DM     (1.0)   OR LESS   CL=.90     DAUM      76 SPEC    M**2= 0.23+-0.54  1/76
M      D      0.57   OR LESS   CL=.90     DAUM      78 SPEC    M**2= 0.13+-0.14  3/78
M      M   WE CALCULATE UPPER LIMIT AT CL=.90 FROM M**2.                         1/76
M    B     BACKENSTOSS 73 REPLACES BACKENSTOSS 71 AND USES THEIR NEW PI- MASS.  1/73
M    S     SHRUM 71 USES SHAFER 67 PI- MASS VALUE AND CRANE 71 MU MASS VALUE.   1/73
M      D   DAUM 78 REPLACES DAUM 76.  EVALUATED USING M(PI)=139.5675+-0.0013    3/78
M      D   AND M(MU)=105.65948+-0.00035.  R. FROSCH, PRIVATE COMM.              3/78
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                        2   (MU-NEUTRINO) - (MU-ANTINEUTRINO) MASS DIFF. (MEV)

DM            0.45   OR LESS   CL=.90     CLARK      74 ASPK KMU3 DECAY          11/75
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                        2   MU-NEUTRINO MEAN LIFE/MASS   (UNITS SEC/EV)

T     B    0  3. E-3    OR MORE   CL=.90    BELLOTTI  76 HLBC NEU, CERN GARGAMELL  1/78
T     B    1  1.3E-2    OR MORE   CL=.90    BELLOTTI  76 HLBC ANTINEU, CERN GARG   1/78
T     B    0  2.2E-3    OR MORE   CL=.90    BARNES    77 DBC  NEU, ANL 12FT.       1/78
T     C      (1. E17)   OR MORE             COWSIK    77 RVUE    ASTROPHYSICS     12/77
T     B    0  2.6E-2    OR MORE   CL=.90    BLIETSCHA 78 HLBC NEU,ANEU CERN,GARGA  1/79*
T            STABLE                         FALK      78        ASTROPHYSICS      12/79*
T     B   THESE EXPERIMENTS LOOK FOR NEU(MU) --> NEU(E) GAMMA.                    1/78
T     C   COWSIK 77 REFERS TO RADIATIVE DECAY OF EITHER NEUE OR NEUMU.           12/77
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                        2   MU-NEUTRINO VELOCITY-C: ABS((V-C)/C) (UNITS 10**-4)
                             EXPECTED TO BE ZERO FOR MASSLESS NEUTRINO

V        77     2.0    OR LESS  CL=.99    ALSPECTOR 76 SPEC >50GEV NEU, K DECAY  1/78
V        26     4.0    OR LESS  CL=.99    ALSPECTOR 76 SPEC <50GEV NEU, PI DCAY  1/78
V      9800     0.4    OR LESS  CL=.95    KALBFLEIS 79 SPEC                     12/79*
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                              REFERENCES FOR MU-NEUTRINO

BARKAS   56 PR 101  778         W H BARKAS,W BIRNBAUM,F M SMITH          (LRL)
DUDZIAK  59 PR 114  336         W F DUDZIAK,R SAGANE,J VEDDER            (LRL)
FEINBERG 63 ARNS 13 431         G FEINBERG, L M LEDERMAN            (COLUMBIA)
ALLCOCK  65 PPSL  85  875       G R ALLCOCK                        (LIVERPOOL)
BARDON   65 PRL  14 449         BARDON,NORTON,PEOPLES +  (COLU+STONY BROOK)
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

ν_μ, μ

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SHAFER    65 PRL  14 923        R E SHAFER,CROWE,JENKINS                  (LRL)
BOOTH     67 PL 26B  39         BOOTH,JOHNSCN,WILLIAMS,WORMALD  (LIVERPOOL)
HYMAN     67 PL 25B 376         +LOKEN,PEWITT,MCKENZIE+        (ANL+CARN+NWES)
BACKENST  71 PL 36B 403         BACKENSTOSS,DANIEL,KOCH+    (CERN,KARL,HEID)
SHRUM     71 PL 37B 114         E V SHRUM,K O H ZIOCK     (UNIV OF VIRGINIA)
COWSIK    72 PRL 29 669         R COWSIK,J MC CLELLAND                  (UCB)
BACKENST  73 PL 43B 539         BACKENSTOSS,DANIEL,KOCH+ (CERN+KARL+MUNICH)

CLARK     74 PR D9 533          +ELIOFF,FRISCH,JOHNSON,KERTH,SHEN +     (LBL)
ALSPECTO  76 PRL 36 837         ALSPECTOR +           (BNL+PURD+CIT+FNAL+ROCK)
BELLOTTI  76 LNC 17 553         +CAVALLI,FIORINI,ROLLIER               (MILA)
DAUM      76 PL 60B 380         +DUBAL,EATCN,FROSCH,MCCULLOCH+     (SIN+ETH)

BARNES    77 PRL 38 1049        +CARMONY,DAUWE,FERNANDEZ +         (PURD+ANL)
COWSIK    77 PRL 39 784         R. COWSIK                          (MPIM+TATA)
     ALSO 79 PR D19 2219        R. COWSIK                               (TATA)
     ALSO 79 PR D19 2215        GOLDMAN,STEPHENSON                      (LASL)

BLIETSCH  78 NP B133 205        AACH+LIBH+CERN+EPOL+MILA+ORSA+LOUC
DAUM      78 PL 74B 126         +EATON,FROSCH,HIRSCHMANN,MCCULLOCH+     (SIN)
FALK      78 PL 79B 511         S. FALK, D. SCHRAMM                      (EFI)

KALBFLEI  79 PRL 43 1361        KALBFLEISCH,BAGGETT,FOWLER+(FNAL+PURD+BELL)

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μ

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                    4  MUON(106,J=1/2)
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                    4  MUON MASS (MEV)

M         (105.659)  (0.002)         FEINBERG  63 RVUE
M         (105.6599) (0.0014)        TAYLOR    69 RVUE     USING NEW E/H    7/70
M    C    (105.6597) (0.0005)        CRANE     71 CNTR INCLUDED IN COHEN73  1/73
M    D    (105.6594) (0.0004)        CROWE     72 CNTR INCLUDED IN CCHEN73  2/72
M          105.65948  0.00035        COHEN     73 RVUE                      3/74
M    A     105.65945  0.00033        CASPERSON 77 CNTR +                   12/77
M    C  CRANE 71 GIVES MU/ME=206.76878(85).  WE USE ME=.5110041(16)MEV.     1/73
M    D  CROWE 72 GIVES MU/ME=206.7682(5) AND USES ME=.5110041(16)MEV.       1/73
M    A  CASPERSON 77 GIVES MU/ME=206.76859(29).WE USE ME=.5110034(14)MEV.  12/77
M               . . . . . . . . .
M    AVG    105.65946  0.00024  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    STUDENT105.65946  0.00026  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M    FIT    105.65946  0.00024 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*

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                    4  MUON MEAN LIFE (UNITS 10**-6)

T              2.198     0.001     0.001 FARLEY     62 CNTR
T              2.203     0.004           LUNDY      62 CNTR     CONLEV=.98    11/67
T              2.202     0.003     0.003 ECKHAUSE   63 CNTR
T              2.197     0.005     0.002 MEYER      63 CNTR +
T              2.198     0.002     0.002 MEYER      63 CNTR -                 7/66
T    W       (2.20026)(0.00081)          WILLIAMS   72 CNTR +                 2/76
T              2.1973    0.0003          DUCLOS     73 CNTR +                 1/76
T              2.19711   0.00008         BALANDIN   74 CNTR +                 1/76
T               2.1948    0.0010         BAILEY2    77 CNTR -  STORAGE RINGS  2/79*
T               2.1966    0.0020         BAILEY2    77 CNTR +  STORAGE RINGS  2/79*
T    W   WILLIAMS 72 MEAN LIFE MEASUREMENT WAS NOT THE PRIMARY PURPOSE OF     1/76
T    W   THEIR EXPERIMENT AND DISAGREES STRONGLY WITH LATER EXPTS. NOT AVGD.  1/76
T              . . . . . . . . .
T    AVG     2.197120 0.000C77 0.000077 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T    STUDENT 2.197123 0.000083 0.000083 AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    4  MU+/MU- MEAN LIFE RATIO

DT             1.000     0.001          MEYER      63 CNTR  MEAN LIFE MU+/MU-   7/66
DT             1.0008    0.0010         BAILEY     79 CNTR   STORAGE RING       7/79*
DT             . . . . . . . . .
DT   AVG       1.00040   0.00071  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
DT   STUDENT   1.00040   0.00077  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    4  MUON ANOMALOUS MAGN. MOMENT (10**-6*E/(2*MU MASS))

MM        SEE RICH 72 AND COMBLEY 74 FOR A REVIEW OF THEORY AND EXPERIMENTS.
MM          (1162.0)     (5.0)           CHARPAK    62 CNTR +
MM   B      (1165.75)    (0.71)          BAILEY     68 CNTR +  STOR. RINGS        5/69
MM   B      (1166.25)    (0.24)          BAILEY     68 CNTR  - STOR. RINGS        5/69
MM   B       ERRORS STATISTICAL. VALUES COMBINED TO GIVE MU+- VALUE BELOW         5/69
MM           1166.16       0.31          BAILEY     68 CNTR +- STOR. RINGS        5/69
MM           1060.         67.           HENRY      69 CNTR +                     1/77
MM   IA     (1165.895)   (0.027)         BAILEY     75 CNTR +  STORAGE RING      11/75
MM   IA     (1165.922)   (0.009)         BAILEY     77 CNTR +- STORAGE RING      11/77
MM   I      (1165.911)   (0.011)         BAILEY     79 CNTR +  STORAGE RING       7/79*
MM   I      (1165.937)   (0.012)         BAILEY     79 CNTR -  STORAGE RING       7/79*
MM   I       1165.924      0.0085        BAILEY     79 CNTR +- STORAGE RING       7/79*
MM   A    BAILEY 77 INCLUDES RESULTS OF BAILEY 75.                               11/77
MM   I    BAILEY 79 IS FINAL RESULT. INCLUDES BAILEY 75 AND 77 DATA.              7/79*
MM   I    THIRD BAILEY 79 RESULT IS FIRST TWO COMBINED.                           7/79*
MM           . . . . . . . . .
MM   AVG     1165.9242     0.0085  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
MM   STUDENT1165.9242      0.0092  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

EDM                    4  MUON ELECTRIC DIPOLE MOMENT (UNITS 10**-19 E-CM)    2/79*
EDM B       (8.6)        (4.5)           BAILEY     78 CNTR +  STORAGE RINGS      2/79*
EDM B       (0.8)        (4.3)           BAILEY     78 CNTR -  STORAGE RINGS      2/79*
EDM  B       3.7          3.4            BAILEY     78 CNTR +- STORAGE RING       2/79*
EDM  B   BAILEY 78 YIELDS EDM < 1.05*10**-18 WITH CL=.95.  THIRD RESULT IS    2/79*
EDM  B   FIRST TWO COMBINED ASSUMING CPT.                                       2/79*

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                    4  MUCN TO PROTON MAGNETIC MOMENT RATIO

MMR       THIS RATIO IS USED TO OBTAIN PRECISE VALUES OF THE MUON MASS.       3/72
MMR       SEE CROWE 72.                                                       3/72
MMR        (3.1865)   (.0022)            COFFIN     58 CNTR +  SPIN RESONANCE   2/72
MMR        (3.1830)   (.0011)            LUNDY      58 CNTR +  PRECESSION STROB 2/72
MMR        (3.176)    (.013)             LUNDY      58 CNTR -  PRECESSION STROB 2/72
MMR        (3.1834)   (.0002)            GARWIN     60 CNTR +  PRECESSION PHASE 2/72
MMR        (3.18336)  (.00007)           BINGHAM    63 CNTR +  PRECESSION STROB 2/72
MMR        (3.1808)   (.0004)            BINGHAM    63 CNTR -  PRECESSION STROB 2/72
MMR        (3.18338)  (.00004)           HUTCHINS   63 CNTR +  PRECESSION PHASE 2/72
MMR D      (3.183351)(.000016)           EHRLICH    69 CNTR    HFS SPLITTING    2/72
MMR C      (3.183314)(.000044)           THOMPSON   69 CNTR    HFS SPLITTING    2/72
MMR        (3.183330)(.000044)           HUTCHINS   70 CNTR +  PRECESSION PHASE 2/72
MMR H      (3.183347)(.000009)           HAGUE      70 CNTR +  PRECESSION PHASE 2/72
MMR  C     (3.183336)(.000013)           CRANE      71 CNTR    HFS SPLITTING    2/72
MMR  D     (3.183345)(.000015)           DEVOE      71 CNTR    HFS SPLITTING    1/73
MMR F      (3.183326)(.000013)           FAVART     71 CNTR    HFS SPLITTING    2/72
MMR  H     (3.1833467(.0000082)          CROWE      72 CNTR +  PRECESSION PHASE 2/72
MMR  R  THE RESULTS THROUGH 1972 ARE INCLUDED IN COHEN.73.                      3/74
MMR  R        3.1833402 .0000072         COHEN      73 RVUE                     3/74
MMR           3.1833299 .0000025         CASPERSON 75 CNTR                      2/76
MMR           3.1833403 .0000044         CASPERSON 77 CNTR +  HFS SPLITTING    12/77
MMR           3.1833448 .0000029         CAMANI     78 CNTR +  PRECESSION STROB 7/79*
MMR C   CRANE 71 SUPERSEDES THOMPSON 69. THIS IS NOT A DIRECT MEASUREMENT.      1/73
MMR H   CROWE 72 SUPERSEDES HAGUE 70.
MMR F   FAVART 71 ASSUMES A ZERO VALUE FOR THE PROTON POLARIZABILITY.           1/73
MMR  D  DEVOE 71 SUPERCEDES EHRLICH 69.  THIS IS NOT A DIRECT MEASUREMENT.      1/73
MMR  D  WE GIVE A NEW VALUE WHICH CONTAINS A THEORETICAL CORRECTION OF          1/73
MMR  D  -7.8+-2.3 PPM, AS DISCUSSED IN FOOTNOTE 35A OF CROWE 72.                1/73
MMR           . . . . . . . . . .
MMR AVG       3.18333710.0000039  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
MMR STUDENT3.18333820.0000032  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                       (SEE IDEOGRAM BELOW )
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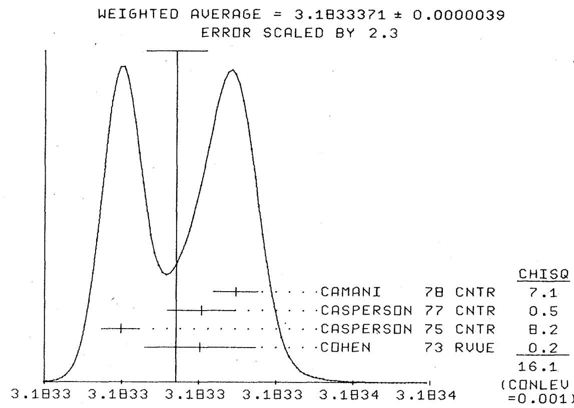

MUON TO PROTON MAGNETIC MOMENT RATIO

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                    4  MUON PARTIAL DECAY MODES

                                                          DECAY MASSES
P1        MUON INTO E ANTI(E-NEU) (MU-NEU)                .5+   0+   0
P2        MUON INTO E 2GAMMA                              .5+   0+   0
P3        MUON INTO 3ELECTRONS                            .5+  .5+  .5
P4        MUCN INTO E GAMMA                               .5+   0
P5        MUON INTO E (E-NEU) ANTI(MU-NEU)                .5+   0+   0
P6        MUON INTO E ANTI(E-NEU) (MU-NEU) GAMMA          .5+   0+   0+   0

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                    4  MUCN BRANCHING RATIOS

R1        MUON INTO E+2GAMMA (IN UNITS OF 10**-5)            (P2)/(P1)
R1              1.6    OR LESS  CL=.90    FRANKEL1  63 OSPK +
R1   P          0.4    OR LESS  CL=.90    POUTISSOU 74 CNTR +                  12/75
R1   P    POUTISSOU 74 LIMIT APPLIES TO SUM OF ALL NEUTRINOLESS MU+ DECAYS.     1/76

R2        MUON INTO 3E (IN UNITS OF 10**-7)                  (P3)/(P1)
R2 F          5.0    OR LESS  CL=.90    PARKER     62 CNTR
R2 F          1.3    OR LESS  CL=.90    ALIKHANOV  62 OSPK
R2 F          1.5    OR LESS  CL=.90    FRANKEL2   63 CNTR
R2 F          1.2    OR LESS  CL=.90    BABAEV     63 OSPK
R2 K          0.062  OR LESS  CL=.90    KORENCH2   71 OSPK                      2/72
R2 K          0.019  OR LESS  CL=.90    KORENCHEN 76 SPEC +                     6/77
R2 F      FOUR ABOVE EXPERIMENTS EVALUATED UPPER LIMITS ASSUMING A SECOND
R2 F      ORDER V-A NEUTRINO LOOP DIAGRAM. LIMITS NOT SIGNIFICANTLY CHANGED
R2 F      BY ASSUMING A CONSTANT MATRIX ELEMENT.
R2 K      THESE EXPERIMENTS ASSUME A CONSTANT MATRIX ELEMENT.                  10/77

R3        MUCN INTO E+GAMMA (IN UNITS OF 10**-8)             (P4)/(P1)
R3            4.3    OR LESS  CL=.90    FRANKEL1   63 OSPK
R3            2.2    OR LESS  CL=.90    PARKER     64 OSPK
R3            2.9    OR LESS  CL=.90    KORENCH1   71 OSPK +                   10/71
R3            0.36   OR LESS  CL=.90    DEPCMMIER 77 CNTR +                    12/77
R3            0.11   OR LESS  CL=.90    POVEL      77 ELEC +                    1/79*
R3            0.019  OR LESS  CL=.90    BOWMAN     79 SPEC +                    7/79*

R4        MUON+ INTO (E+ (E-ANTINEU) (MU-NEU))               (P5)/(P1)
R4        FORBIDDEN BY ADDITIVE CONSERVATIVATION LAW FOR MUON NUMBER.
R4        MULTIPLICATIVE LAW PREDICTS R4=0.5
R4            0.25   OR LESS  CL=.90    EICHTEN    73 HLBC +                   11/75

R5        MUON INTO E ANTI(E-NEU) (MU-NEU) GAMMA             (P6)/(P1)          1/78
R5          27 EVENTS SEEN                  ASHKIN     59 CNTR                  1/78
R5              1.4E-2    0.4E-2            CRITTENDE 61 CNTR T(GAM) GT 10 MEV  1/78
R5              3.3E-3    1.3E-3            CRITTENDE 61 CNTR T(GAM) GT 20 MEV  1/78
R5        862 EVENTS SEEN                   BOGART     67 CNTR T(GAM) GT 14.5 MEV 1/78

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                    4  MUON DECAY PARAMETERS

       RELATED TEXT SECTION VI A

RHO      RHO PARAMETER                      (V-A THEORY PREDICTS RHO=0.75)
RHO C             (0.741)   (0.027)         DUDZIAK    59 CNTR +  20-53 MEV E+    10/69
RHO  P9213         0.745     0.025          PLANO      60 HBC  +  WHOLE SPECTRUM  10/69
RHO   P  TWO PARAMETER FIT TO RHO AND ETA.
RHO C 2276     (0.751)   (0.034)            BLOCK      62 HEBC  - WHOLE SPECTRUM  10/69
RHO D             (0.64)    (0.04)          BARLOW     64 CNTR  - WHOLE SPECTRUM  10/69
RHO D             (0.661)   (0.016)         BARLOW     64 CNTR +  WHOLE SPECTRUM  10/69
RHO D             (0.867)   (0.035)         PONTECORV 64 CC     -                 10/69
RHO D    RESULTS IN DOUBT.                                                        10/69
RHO C 800K     (0.7503)  (0.0026)           PEOPLES    66 ASPK +  20-53 MEV E+    10/69
RHO C 280K     (0.760)   (0.009)            SHERWOOD  67 ASPK +  25-53 MEV E+     10/69
RHO C 170K     (0.762)   (0.008)            FRYBERGER 68 ASPK +  25-53 MEV E+     10/69
RHO C    ETA CONSTRAINED =0. THESE VALUES INCORPORATED INTO A TWO PARAMETER
RHO C    FIT TO RHO AND ETA BY DERENZO 69.
RHO            0.7518    0.0026             DERENZO    69 RVUE                    10/69
RHO            . . . . . . . . .
RHO AVG        0.7517    0.0026  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
RHO STUDENT    0.7517    0.0028  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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Stable Particles

μ, ν_τ, $\tau^\pm$

Data Card Listings

For notation, see key at front of Listings.

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ETA     ETA PARAMETER                  (V-A THEORY PREDICTS ETA=0)
ETA P 9213  (-2.0)     (0.9)           PLANO     60 HBC  +  WHOLE SPECTRUM    10/69
ETA P   TWO PARAMETER FIT TO RHO AND ETA- PLANO 60 DISCOUNTS VALUE FOR ETA   10/69
ETA C 800K   (0.05)    (0.5)           PEOPLES   66 ASPK +  20-53 MEV E+      10/69
ETA C 280K   (-0.7)    (0.6)           SHERWOOD  67 ASPK +  25-53 MEV E+      10/69
ETA C 170K   (-0.7)    (0.5)           FRYBERGER 68 ASPK +  25-53 MEV E+      10/69
ETA C   RHO CONSTRAINED =0.75.
ETA   6346   -0.12      0.21           DERENZO   69 HBC  +  1.6-6.8 MEV E+    10/69

XSI     XSI PARAMETER                  (V-A THEORY PREDICTS XSI=1)
XSI      9K    0.97      0.05          BARDON    59 CNTR   BROMOFORM TARGET 10/69
XSI    8354    0.93      0.06          PLANO     60 HBC  +  8.8 KGAUSS        10/69
XSI A         (0.903)   (0.027)        ALI-ZADE  61 EMUL +  27 KGAUSS         10/69
XSI A   DEPOLARIZATION BY MEDIUM NOT KNOWN SUFFICIENTLY WELL.
XSI G   66K   (0.975)   (0.030)        GUREVICH  64 EMUL    140 KGAUSS        10/69
XSI            0.975     0.014         GUREVICH  67 EMUL                      10/69
XSI G   GUREVICH 67 SUPERSEDES GUREVICH 64                                    10/69
XSI           . . . . . . . . .
XSI AVG        0.972     0.013   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
XSI STUDENT    0.973     0.014   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

DEL     DELTA PARAMETER                (V-A THEORY PREDICTS DELTA=0.75)
DEL   8354     0.78      0.05          PLANO     60 HBC  +  WHOLE SPECTRUM    10/69
DEL            0.782     0.031         KRUGER    61                           10/69
DEL    490K    0.752     0.009         FRYBERGER 68 ASPK +  25-53 MEV E+      10/69
DEL     VOSSLER 69 HAS MEASURED THE ASYMMETRY BELOW 10 MEV                    11/69
DEL           . . . . . . . . .
DEL AVG        0.7551    0.0085  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
DEL STUDENT    0.7550    0.0094  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

HEL     HELICITY OF DECAY ELECTRON.
HEL      (V-A THEORY PREDICTS HELICITY=+-1 FOR E+-, RESPECTIVELY)
HEL     WE HAVE FLIPPED THE SIGN FOR E- SO OUR PROGRAMS CAN AVERAGE
HEL D         (0.28)    (0.16)         DICK      63 CNTR +  ANNIHILATION      10/69
HEL D   IN DOUBT- POSITRONS POSSIBLY DEPOLARIZED IN BE MODERATOR.
HEL            1.05      0.30          BUHLER    63 CNTR +  ANNIHILATION      10/69
HEL            0.94      0.38          BLOOM     64 CNTR +  BREMS TRANSMISS   10/69
HEL            1.04      0.18          DUCLOS    64 CNTR +  BHABHA SCATT      10/69
HEL     29K    0.89      0.28          SCHWARTZ  67 OSPK  - MOLLER SCATT      10/69
HEL           . . . . . . . . .
HEL AVG        1.00      0.13    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
HEL STUDENT    1.00      0.14    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

GS      SCALAR COUPLING CONSTANT IN MUON DECAY  (IN UNITS OF GV)
GS             0.33  OR LESS           DERENZO   69 RVUE                      10/69

GA      AXIAL VECTOR COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)
GA             0.86      0.33    0.11  DERENZO   69 RVUE                      10/69

FAV     PHASE BETWEEN VECTOR AND AXIAL VECTOR COUPLINGS  (DEGREES)
FAV          180.       15.            DERENZO   69 RVUE                      10/69

GT      TENSOR COUPLING CONSTANT IN MUON DECAY    (IN UNITS OF GV)
GT             0.28  OR LESS           DERENZO   69 RVUE                      10/69

GP      PSEUDOSCALAR COUPLING CONSTANT IN MUON DECAY  (IN UNITS OF GV)
GP             0.33  OR LESS           DERENZO   69 RVUE                      10/69

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REFERENCES FOR MUON


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COFFIN    58 PR 109 973          +GARWIN,PENMAN,LEDERMAN,SACHS     (COLUMBIA)
LUNDY     58 PRL 1 38            +SENS,SWANSON,TELEGDI,YOVANOVITCH (CHICAGO)
ASHKIN    59 NC 14 1266          +FAZZINI,FIDECARO,LIPMAN,MERRISON +  (CERN)
BARDON    59 PRL   2   56        M BARDON, D BERLEY, L LEDERMAN    (COLUMBIA)
DUDZIAK   59 PR  114  336        W DUDZIAK,R SAGANE, J VEDDER           (LRL)
GARWIN    60 PR 118 271          GARWIN,HUTCHINSON,PENMAN,SHAPIRO (COLUMBIA)
PLANO     60 PR  119 1400        R J PLANO                         (COLUMBIA)

ALI-ZADE 61 JETP  13  313        ALI-ZADE,GUREVICH,NIKOLSKI            (USSR)
CRITTEND 61 PR 121 1823          CRITTENDEN,WALKER,BALLAM         (MSU+MICH)
KRUGER    61 UCRL-9322 (UNPUB) H KRUGER                                 (LRL)
ALIKHANO 62 CERN CONF 423        A I ALIKHANOV,A BABAEV +      (ITEP MOSCOW)
BLOCK     62 NC    23  1114      BLOCK,FIORINI,KIKUCHI+(DUKE,BOLOGNA,MILANO)
CHARPAK  62 PL      1  16        G CHARPAK,F J M FARLEY,R L GARWIN +  (CERN)
FARLEY    62 CERN CONF 415       FARLEY,MASSAM,MULLER,ZICHICHI         (CERN)

LUNDY     62 PR 125 1686         RICHARD A LUNDY                        (EFI)
PARKER    62 NC  23   485        S PARKER,S PENMAN                      (EFI)
BABAEV    63 JETP 16 1397        BABAEV,BALATS,KAFTANOV,LANDSBERG +   (ITEP)
BINGHAM   63 NC 27 1352          G.MCD.BINGHAM                          (LRL)
BUHLER    63 PL     7  368       +CABIBBO,FIDECARO,MASSAM,MULLER+      (CERN)
DICK      63 PL     7  150       DICK,FEUVRAIS,SPIGHEL                 (CERN)

ECKHAUSE 63 PR 132  422          M ECKHAUSE,T A FILIPPAS +        (CARNEGIE)
FEINBERG 63 ARNS 13 431          GERALD FEINBERG, L M LEDERMAN    (COLUMBIA)
FRANKEL1 63 NC  27   894         S FRANKEL,W FRATI,J HALPERN +         (PENN)
FRANKEL2 63 PR 130  351          S FRANKEL,W FRATI,J HALPERN +         (PENN)
HUTCHINS 63 PR 131 1351          HUTCHINSON,MENES,PATLACH,SHAPIRO (COLUMBIA)
MEYER     63 PR  132  2693       S L MEYER,ANDERSON,BLESER,LEDERMAN+  (COLU)

BARLOW    64 PPS   84  239       +BOOTH,CARROL,COURT,DAVIES,EDWARDS+  (LIVP)
BLOOM     64 PL    8   87        +DICK,FEUVRAIS,HENRY,MACQ,SPIGHEL     (CERN)
DUCLOS    64 PL    9   62        +HEINTZE,DE RUJULA,SOERGEL            (CERN)
GUREVICH 64 PL    11  185        GUREVICH,MAKARIYNA+                   (KIAE)
PONTECOR 64 DUBNA CONF           PONTECORVO,SULYAEV                  (MOSCOW)
PARKER    64 PR 133B 768         S PARKER,H L ANDERSON,C REY            (EFI)

PEOPLES   66 NEVIS-147 (UNPUB) J PEOPLES                          (COLUMBIA)
BOGART    67 PR 156 1405         +DICAPUA,NEMETHY,STRELZOFF            (COLU)
GUREVICH 67  IAE 1297            GUREVICH,MAKARIYNA,MISHAKOVA+         (KIAE)
SCHWARTZ 67 PR  162 1306         D M SCHWARTZ                           (EFI)
SHERWOOD 67 PR  156 1475         B A SHERWOOD                           (EFI)
BAILEY    68 PL    28B  287      +BARTL,VON BOCHMANN,BROWN,FARLEY+     (CERN)
    ALSO 72 NC 9A 369            +BARTL,VON BOCHMANN,BROWN,FARLEY+     (CERN)
FRYBERGE 68 PR  166 1379         D FRYBERGER                            (EFI)

DERENZO   69 PR  181 1854        S DERENZO                              (EFI)
EHRLICH   69 PRL 23 513          +HOFER,MAGNON,STOWELL,SWANSON+     (CHICAGO)
HENRY     69 NC 63A 995          +SCHRANK,SWANSON              (STAN+UCSB+UCSD)
TAYLOR    69 RMP 41 375          +PARKER,LANGENBERG           (PRIN+UCI+PENN)
THOMPSON 69 PRL 22 163           +AMATO,CRANE,HUGHES,MOBLEY+           (YALE)
HAGUE     70 PRL 25 628          +ROTHBERG,SCHENCK,WILLIAMS+       (WASH+LRL)
HUTCHINS 70 PRL 24 1254          HUTCHINSON,LARSON,SCHOEN,SOBER,+       (PPA)

CRANE     71 PRL 27 474          +CASPERSON,CRANE,EGAN,HUGHES+         (YALE)
DEVOE     71 PRL 25 1779(ER)     +MCINTGRE,MAGNON,STOWELL,SWANSON+ (CHICAGO)
    ALSO 71 PRL 26 213           DEVOE,MCINTGRE,MAGNON,STOWELL+     (CHICAGO)
FAVART    71 PRL 27 1336         +MCINTYRE,STOWELL,TELEGDI,DEVOE+   (CHICAGO)
KORENCH1 71 SJNP 13 190          KORENCHENKO,KOSTIN,MICELMACHER+       (JINR)
KORENCH2 71 SJNP 13 728          KORENCHENKO,KOSTIN,MICELMACHER+       (JINR)

CROWE     72 PR D5 2145          +HAGUE,ROTHBERG,SCHENCK+          (LBL+WASH)
WILLIAMS 72 PR D6 737            R W WILLIAMS,D L WILLIAMS       (WASHINGTON)
COHEN     73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
DUCLOS    73 PL 47B 491          +MAGNON,PICARD                        (SACL)
EICHTEN   73 PL 46B 281          +DEDEN+(AACH+BELG+CERN+EPOL+MILA+LALO+LOUC)

BALANDIN 74 JETP 40 811          +GREBENYUK,ZINOV,KONIN,PONOMAREV      (JINR)
POUTISSO 74 NP B80 221           POUTISSOU,FELAWKA,INGRAM +       (MONT+BRCO)
BAILEY    75 PL 55B 420          +BORER+(CERN+DARE+BERN+SHEF+MANZ+RMCS+BIRM)
CASPERSO 75 PL 59B 397           CASPERSON,CRANE+ (YALE+LASL+HEID+BERN+WYOM)
KORENCHE 76 JETP 43 1            KORENCHENKO,KOSTIN,MITSELMAKHER+      (JINR)

BAILEY    77 PL 67B 225          +BORER+(CERN+CARE+BERN+SHEF+MANZ+RMCS+BIRM)
       OR 77 PL 68B 191          +BORER+/CERN+DARE+BERN+SHEF+MANZ+RMCS+BIRM
BAILEY2   77 NATURE 268 301           (DARE+BERN+SHEF+CERN+MANZ+RMCS+BIRM)
    ALSO 79 BAILEY
CASPERSO 77 PRL 38 956           CASPERSON,CRANE+ (BERN+HEID+LASL+WYOM+YALE)
DEPOMMIE 77 PRL 39 1113          DEPOMMIER,MARTIN+(MONT+BRCO+TRIU+VICT+MELB)
POVEL     77 PL 72B 183          +DEY,WALTER,PFEIFFER +         (ZURI+ETH+SIN)
BAILEY    78 JPG 4 345                (DARE+BERN+SHEF+MANZ+RMCS+CERN+BIRM)
    ALSO 79 BAILEY
CAMANI    78 PL 77B 326          +GYGAX,KLEMPT,RUEGG,SCHENCK+      (ETH+MANZ)
BAILEY    79 NP B150 1             (DARE+BERN+SHEF+MANZ+RMCS+CERN+BIRM+LBL+)
BOWMAN    79 PRL 42 556          +COOPER,HAMM,HOFFMAN +       (LASL+EFI+STAN)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

FISHER    59 PRL  3  349         FISHER,LEONTIC,LUNDBY,MEUNIER,STROOT (CERN)
ASTBURY   60 ROCH CONF 60 542    ASTBURY,HATTERSLEY,HUSSAIN +   (LIVERPOOL)
DEVONS    60 PRL  5  330         DEVONS,GIDAL,LEDERMAN,SHAPIRO    (COLUMBIA)
LATHROP   60 NC   17 109         J LATHROP,R A LUNDY,V L TELEGDI +      (EFI)
LATHROP   60 NC   17 114         J LATHROP,R A LUNDY,S PENMAN +         (EFI)
REITER    60 PRL   5  22         REITER,ROMANOWSKI,SUTTON +       (CARNEGIE)
TELEGDI   60 ROCH CONF 60 713    V L TELEGDI                           (CERN)

CHARPAK   61 PRL   6 128         CHARPAK,FARLEY,GARWIN,MULLER,SENS +  (CERN)
HUTCHINS 61 PRL   7 129          D P HUTCHINSON,J MENES +         (COLUMBIA)
SHAPIRO   62 PR 125 1022         G SHAPIRO,L M LEDERMAN           (COLUMBIA)
FAIRLEY   66 NC 45A 281          FAIRLEY,BAILEY,BROWN,GIESCH +         (CERN)
VOSSLER   69 NC 63A 423          C VOSSLER                              (EFI)
RICH      72 RMP 44 250          A RICH,J C WESLEY                     (MICH)
COMBLEY   74 PRPL 14 1           F.COMBLEY,E.PICASSO                   (CERN)
FARLEY    79 ARNPS - TO BE PUB FARLEY,PICASSO                     (RMCS+CERN)
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                  36  TAU NEUTRINO

                  NOT YET ESTABLISHED.
                  OMITTED FROM TABLE.

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                  36  TAU NEUTRINO MASS (MEV)

M     P 144  600.    OR LESS  CL=.95   PERL      77 SMAG E+E-3.8-7.8GEV ECM  12/77
M            740.    OR LESS  CL=.90   BRANDELIK 78 DASP ASSUMES V-A DECAY    3/78
M           (540.)   OR LESS  CL=.90   BRANDELIK 78 DASP ASSUMES V+A DECAY    3/78
M     B 594  250.    OR LESS  CL=.95   BACINO    79 DLCO E+E- ECM=3.5-7.4GEV  7/79*
M     P  PERL 77 IS E+E- TO TAU+ TAU- EXPT. VALUE QUOTED ASSUMES V-A DECAY   12/77
M     P  AND TAU MASS=1900 MEV.                                               12/77
M     B  BACINO 79 EXPT RULES OUT V+A DECAY.                                   7/79*

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REFERENCES FOR TAU NEUTRINO


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PERL      77 PL 70B 487          +FELDMAN,ABRAMS,ALAM,BOYARSKI+    (SLAC+LBL)
BRANDELI 78 PL 73B 109           BRANDELIK +        (AACH+DESY+HAMB+MPIM+TOKY)
BACINO    79 PRL 42 749          +FERGUSON,NODULMAN+     (UCLA+SLAC+UCI+STON)
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                  35  TAU+-(1800,J=1/2) HEAVY LEPTON

                  E+E- --> TAU+TAU- CROSS SECTION THRESHOLD BEHAVIOR
                  AND MAGNITUDE CONSISTENT WITH POINTLIKE SPIN 1/2
                  DIRAC PARTICLE.  BRANDELIK 78 RULES OUT POINTLIKE
                  SPIN 0 OR SPIN 1 PARTICLE.

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                  35  TAU MASS (MEV)

M    P   64(1800.)   (200.)                PERL      75 SMAG   INCL. IN PERL 77  2/78
M     B 220(1910.)    (30.)                BURMEST1  77 PLUT ASSUMES V-A DECAY 12/77
M     B 220(1790.)    (70.)                BURMEST1  77 PLUT ASSUMES V+A DECAY 12/77
M     P 144(1900.)   (100.)                PERL      77 SMAG E+E- 3.8-7.8GEV ECM 12/77
M     A 692 1782.       2.        7.       BACINO    78 DLCO E+E- ECM=3.1-7.4GEV  1/79*
M     R 299 1787.      10.       18.       BARTEL    78 SPEC E+E- 3.6-4.4GEV ECM  7/79*
M           1807.      20.                 BRANDELIK 78 DASP E+E- 3.1-5.2GEV ECM  3/78
M     B  BURMESTER 77 MASS VALUE ARE FROM EVENTS CONTAINING MU+- PLUS ONE     12/77
M     B  OTHER PRONG, ORIGINATING FROM E+ E- --> TAU+ TAU-. THE MASS          12/77
M     B  VALUES COME FROM A FIT TO THE SHAPE AND ECM DEPENDENCE OF THE        12/77
M     B  MU+- SPECTRA, ASSUMING THAT THE TAU SPIN IS 1/2 AND ITS ASSOC        12/77
M     B  NEUTRINO HAS M=0.                                                    12/77
M     P  PERL 77 VALUE COMES FROM E+ E- TO E+- MU-+ AND NO OTHER DETECTED     12/77
M     P  PARTICLES. ASSUMES V-A COUPLING AND ZERO MASS FOR ASSOC NEUTRINO.   12/77
M     A  BACINO 78 VALUE COMES FROM CS THRESHHOLD. SEE 70 EVENTS BELOW         1/79*
M     A  CHARM THRESHHOLD. ENERGY DEPENDENCE CONFIRMS SPIN 1/2.                1/79*
M     R  BARTEL 78 FITS ENERGY DEPENDENCE OF CS FOR E+- AND MU+- EVENTS.       7/79*
M     R  MASS VALUE NOT DEPENDENT ON WHETHER V-A OR V+A DECAY ASSUMED.         7/79*
M           . . . . . . . . .
M    AVG     1783.5      4.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    STUDENT1783.4       4.6     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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                  35  TAU MEAN LIFE  (UNITS 10**-12SEC)

T       77   (9.0)  OR LESS  CL=.95   ALEXANDER 79 PLUT E+E- 3.9-5 GEV ECM   7/79*
T      594   (2.3)  OR LESS  CL=.95   BACINO2   79 DLCO E+E- ECM=3.5-7.4GEV  7/79*

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                  35  TAU PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      TAU+- INTO MU+- NEU(MU) NEU(TAU)                  105+   0+   0
P2      TAU+- INTO E+- NEU(E) NEU(TAU)                     .5+   0+   0
P3      TAU+- INTO E+- GAMMA(S)                            .5+   0
P4      TAU+- INTO MU+- GAMMA(S)                          105+   0
P5      TAU+- INTO E+- CHARGED PARTICLES
P6      TAU+- INTO MU+- CHARGED PARTICLES
P7      TAU+- INTO HADRON+- NEUTRALS
P8      TAU+- INTO 3 HADRONS+- NEUTRALS
P9      TAU+- INTO NEU(TAU) RHO0 PI+-                        0+ 776+ 139
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

$\tau^{\pm}$, $\pi^{\pm}$

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P10     TAU+- INTO NEU(TAU) A1(1100)+-                          0+1100
P11     TAU+- INTO K+- NEUTRALS
P12     TAU+- INTO NEU(TAU) PI+-                                0+ 139
P13     TAU+- INTO NEU(TAU) 2PI+- PI-+ (INCL. P9, P10)          0+ 139+ 139+ 139
P14     TAU+- INTO NEU(TAU) 2PI+- PI-+ (PIOS) (INCL. P13)       0+ 139+ 139+ 139
P15     TAU+- INTO NEU(TAU) AND 3 OR MORE CHGD. PARTICLES
P16     TAU+- INTO NEU(TAU) RHO+-                               0+ 776

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 9	P12	P13	P14	P16	
P 1	.1791+-.0153							
P 2	-.1651	.1698+-.0109						
P 9	.0353	-.2140	.0424+-.0127					
P12	.0341	-.2063	.0442	.0824+-.0255				
P13	-.1222	.0202	-.0043	-.0042	.0726+-.0506			
P14	-.2216	.0366	-.0078	-.0075	.0271	.1787+-.0687		
P16	-.2277	-.1154	.0247	.0238	.0278	.0504	.2175+-.04	10/70

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                      35  TAU BRANCHING RATIOS

R1      TAU+- INTO (MU+- NEU(MU) NEU(TAU))/TOTAL              (P1)
R1      220    0.15     0.03              BURMEST1  77 PLUT ASSUMES V-A DECAY    12/77
R1      220   (0.19)   (0.04)             BURMEST1  77 PLUT ASSUMES V+A DECAY    12/77
R1             0.175    0.040             PERL      77 SMAG    E+E- TO MU+- X-+ 12/77
R1             0.22     0.10      0.07    CAVALLISF 77 SPEC    E+E- TO MU+- X-+  1/78
R1   S  11     0.22     0.07      0.08    SMITH     78 SPEC    E+E- TO MU+MU-X0  7/79*
R1           . . . . . . . . . . .
R1   AVG       0.168    0.022   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1   STUDENT   0.168    0.024   AVERAGE USINC STUDENT10(H/1.11) -- SEE MAIN TEXT
R1   FIT       0.179    0.015  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2      TAU+- INTO (E+- NEU(E) NEU(TAU))/TOTAL                (P2)
R2    B 459    0.160    0.013             BACINO     78 DLCO E+E- ECM=3.1-7.4GEV  1/79*
R2    B  BACINO 78 VALUE COMES FROM FIT TO EVENTS WITH E+- AND 1 OTHER            1/79*
R2    B  NONELECTRON CHARGED PRONG.                                               1/79*
R2           . . . . . . . . . . .
R2   FIT       0.170    0.011  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      TAU+- INTO (L+- NEU(L) NEU(TAU))/TOTAL                SQRT(P1*P2)
R3       WHERE L MEANS E OR MU.  EQUALITY OF E AND MU MODES IS ASSUMED.
R3    P 105    0.17     0.06      0.03    PERL       76 SMAG                      3/77
R3    B 144    0.186    0.030             PERL       77 SMAG                     12/77
R3    B  21    0.224    0.055             BARBARO-G 77 SMAG                      11/77
R3    B  13    0.182    0.031             BRANDELIK 78 DASP ASSUMES V-A DECAY     3/78
R3   B   13   (0.206)  (0.036)            BRANDELIK 78 DASP ASSUMES V+A DECAY     3/78
R3    B  WE HAVE COMBINED STATISTICAL AND SYSTEMATIC ERRORS QUADRATICALLY.        3/78
R3    P  ASSUMES V-A COUPLING, TAU MASS=1.8 GEV, TAU NEUTRINO MASS=0.
R3    B  ASSUMES V-A COUPLING, TAU MASS=1.9 GEV, TAU NEUTRINO MASS=0.
R3           . . . . . . . . . . .
R3   AVG       0.186    0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3   STUDENT   0.186    0.020   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3   FIT       0.1744   0.0085 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4      TAU+- INTO E+- NEU(E) NEU(TAU)/MU+- NEU(MU) NEU(TAU)(P2)/(P1)
R4       PREDICTED TO BE 1 FOR SEQUENTIAL LEPTON, 2 FOR PARAELECTRON,
R4       AND 1/2 FOR PARAMUON. PARAELECTRON ALSO RULED OUT BY HEILE 78.
R4      21     0.92     0.37              BURMEST2  77 PLUT ASSUMES V-A DECAY    12/77
R4      21    (0.67)   (0.28)             BURMEST2  77 PLUT ASSUMES V+A DECAY    12/77
R4    B  18    1.09     0.38              BRANDELIK 78 DASP E+E- 3.1-5.2GEV ECM 12/78*
R4    B  BRANDELIK 78 QUOTES THE INVERSE OF THIS RATIO AS .92+-.32 .             12/78*
R4           . . . . . . . . . . .
R4   AVG       1.00     0.27    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4   STUDENT   1.00     0.29    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R4   FIT       0.95     0.11   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5      TAU+- INTO (MU+- NEU(MU) NEU(TAU))*(E+- NEU(E) NEU(TAU)) (P1)*(P2)
R5             0.034    0.006             ABRAMS     79 SMAG                    12/79*
R5    B  20    0.034    0.009             BACINO1    79 DLCO E+E- ECM=3.6-7.4GEV  1/79*
R5    B  BACINO1 79 QUOTES BR(MU)=0.21+-0.058(STAT.+SYST. ERRORS COMBINED IN  1/79*
R5    B  QUADRATURE) ASSUMING BR(E)=0.16.  WE MPY. BY 0.16 TO GET ABOVE VAL.  1/79*
R5           . . . . . . . . . . .
R5   AVG       0.0340   0.0050  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5   STUDENT   0.0340   0.0054  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R5   FIT       0.0304   0.0030 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6      TAU+- INTO(E+- GAMMA(S) + MU+- GAMMA(S))/TOTAL    (P3+P4)
R6    B        0.12  OR LESS  CL=.90   BURMEST2  77 PLUT E+E- 4-5 GEV ECM    12/77
R6    B  ASSUMES SAME MU,E MOM. SPEC. AS (MU E + NOTHING DETECTED).          12/77

R7      TAU+- INTO(E+- CHARGED PRONG + MU+- CHARGED PRONG)/TOTAL (P5+P6)
R7    B        0.04  OR LESS  CL=.90   BURMEST2  77 PLUT E+E- 4-5 GEV ECM    12/77
R7    B  ASSUMES SAME MU,E MOM. SPEC. AS (MU E + NOTHING DETECTED).          12/77

R8      TAU+- INTO (HADRON+- NEUTRALS)/(TOTAL)                (P7)           11/77
R8      19     0.45     0.19              BARBARO-G 77 SMAG                  11/77
R8             0.29     0.11              BRANDELIK 78 DASP ASSUMES V-A DECAY  3/78
R8            (0.21)   (0.10)             BRANDELIK 78 DASP ASSUMES V+A DECAY  3/78
R8           . . . . . . . . . . .
R8   AVG       0.330    0.095   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8   STUDENT   0.33     0.10    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R9      TAU+- INTO (K+- NEUTRALS)/TOTAL                       (P11)
R9    B     SMALL                         BRANDELIK 77 DASP    3.6-5.2ECM E+E-   1/78
R9    B  BRANDELIK 77 FINDS 0.07+-0.06 K+- PER EVT IN E+E- --> E+- PRONG-+.      1/78

R10     TAU+- INTO (3 HADRONS+- NEUTRALS)/TOTAL               (P8)
R10            0.35     0.11              BRANDELIK 78 DASP ASSUMES V-A DECAY  3/78
R10           (0.38)   (0.11)             BRANDELIK 78 DASP ASSUMES V+A DECAY  3/78

R11     TAU+- INTO (NEU RHO0 PI+-)*(E+- NEU NEU)              (P9)*(P2)
R11   A  21    0.0072   0.0021            ALEXAND1  78 PLUT E+E- 4-5 GEV ECM   3/78
R11   A  ALEXANDER1 78 REPORTS BR(NEU RHO0 PI)=0.045+-0.013 FOR                3/78
R11   A  BR(E NEU NEU)=0.16 AND M(TAU)=1.8 GEV. WE MPY. BY 0.16 TO GET         3/78
R11   A  ABOVE VAL.                                                            3/78
R11          . . . . . . . . . . .
R11 FIT        0.0072   0.0021 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R12     TAU+- INTO (NEU A1(1100)+-)/TOTAL                      (P10)
R12 A    21    (0.10)   (0.03)            ALEXAND1  78 PLUT E+E- 4-5 GEV ECM    12/78*
R12 A    NOT INDEPENDENT OF ALEXANDER1 78 R11 VALUE ABOVE.  ASSUMES THAT ALL 12/78*
R12 A    (NEU RHO0 PI+-) EVENTS ARE (NEU A1+-) AND THAT BR(E+- NEU NEU)=.16. 12/78*

R13     TAU+- INTO (NEU 2PI+- PI-+ (PIOS))*(MU+- NEU NEU) (P14)*(P1)
R13  J   33    0.032    0.012             JAROS      78 SMAG E+E- ECM > 6 GEV     1/79*
R13  J   JAROS 78 FINDS BR(NEU 3PI (PIOS))=.18+-.065 ASSUMING BR(MU)=0.18.    1/79*
R13  J   WE MULTIPLY TO OBTAIN ABOVE VALUE.
R13          . . . . . . . . . . .
R13 FIT        0.032    0.012  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R14     TAU+- INTO (NEU 2PI+- PI-+)*(MU+- NEU NEU)             (P13)*(P1)
R14  J   13    0.013    0.009             JAROS      78 SMAG E+E- ECM > 6 GEV     1/79*
R14  J   JAROS 78 FINDS BR(NEU 3PI)=.07+-.05 ASSUMING BR(MU)=0.18.  WE         1/79*
R14  J   MULTIPLY TO OBTAIN ABOVE VALUE.  EVENTS CONSISTENT WITH BEING
R14  J   RHO PI OR A1.
R14          . . . . . . . . . . .
R14 FIT        0.0130   0.0090 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R15     TAU+- INTO (NEU(TAU) .GE. 3 CHARGED PARTICLES)/TOTAL (P15)
R15     692    0.32     0.05              BACINO     78 DLCO E+E- ECM=3.1-7.4GEV  1/79*

R16     TAU+- INTO (NEU(TAU) PI+-)*(E+- NEU(E) NEU(TAU)) (P12)*(P2)
R16  A   23    0.015    0.006             ALEXAND2  78 PLUT E+E- ECM=3.6-5 GEV    2/79*
R16  B   10    0.013    0.006             BACINO1    79 DLCO E+E- ECM=3.6-7.4GEV  1/79*
R16  A   ALEXANDER2 78 QUOTE BR(PI)=.090+-.038(STAT.+SYST.ERRORS COMBINED IN  2/79*
R16  A   QUADRATURE) USING BR(E)=.167+-.010. WE MPY. BY .167 TO GET ABV.VAL.  2/79*
R16  B   BACINO1 79 QUOTES BR(PI)=0.080+-0.035(STAT.+SYST.ERRORS COMBINED IN  1/79*
R16  B   QUADRATURE) ASSUMING BR(E)=0.16.  WE MPY. BY 0.16 TO GET ABOVE VAL.  1/79*
R16          . . . . . . . . . . .
R16 AVG        0.0140   0.0042  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R16 STUDENT    0.0140   0.0046  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R16 FIT        0.0140   0.0042 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R17     TAU+- INTO (NEU(TAU) RHO+-)*(E+- NEU(TAU) NEU(E)) (P16)*(P2)         12/79*
R17            0.0421   0.0090            ABRAMS     79 SMAG                       12/79*
R17          . . . . . . . . . . .
R17 FIT        0.0369   0.0069 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R18     TAU+- INTO (NEU(TAU) RHO+-)*(MU+- NEU(TAU) NEU(MU)) (P16)*(P1)       12/79*
R18            0.0329   0.0100            ABRAMS     79 SMAG                       12/79*
R18          . . . . . . . . . . .
R18 FIT        0.0389   0.0072 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                     REFERENCES FOR TAU(1800) HEAVY LEPTON

PERL      75 PRL 35 1489        +ABRAMS,BOYARSKI,BREIDENBACH +    (LBL+SLAC)
PERL      76 PL 63B 466         +FELDMAN,ABRAMS,ALAM,BOYARSKI +  (SLAC+LBL)

BARBARO-  77 PRL 39 1058        BARBARO-GALTIERI+       (LBL+NWES+SLAC+HAWA)
BRANDELI  77 PL 70B 125         BRANDELIK +        (AACH+DESY+HAMB+MPIM+TCKY)
BURMEST1  77 PL 68B 297         BURMESTER,CRIEGEE +   (DESY+HAMB+SIEG+WUPG)
BURMEST2  77 PL 68B 301         BURMESTER,CRIEGEE +   (DESY+HAMB+SIEG+WUPG)
CAVALLIS  77 LNC 20 337         CAVALLI-SFORZA,GOGGI +        (PAVI+PRIN+UMD)
PERL      77 PL 70B 487         +FELDMAN,ABRAMS,ALAM,BOYARSKI+    (SLAC+LBL)

ALEXAND1  78 PL 73B 99          ALEXANDER,CRIEGEE+     (DESY+AACH+SIEG+WUPG)
ALEXAND2  78 PL 78B 162         ALEXANDER+         (DESY+AACH+HAMB+SIEG+WUPG)
BACINO    78 PRL 41 13          +FERGUSON,NODULMAN +    (UCLA+SLAC+UCI+STON)
BARTEL    78 PL 77B 331         +DITTMANN,DUINKER,OLSSON,ONEILL+(DESY+HEID)

BRANDELI  78 PL 73B 109         BRANDELIK +      (AACH+DESY+HAMB+ MPIM+TCKY)J
HEILE     78 NP B138 189        +PERL,ABRAMS,ALAM,BOYARSKI+        (SLAC+LBL)
JAROS     78 PRL 40 1120        +ABRAMS,ALAM+              (SLAC+LBL+NWES+HAWA)
SMITH     78 PR D18 1           +FORD,MORSE,MANN,RESVANIS+ (COLO+PENN+WISC)

ABRAMS    79 PRL 43 1555        +ALAM,BLOCKER,BOYARSKI+             (SLAC+LBL)
ALEXANDE  79 PL 81B 84          ALEXANDER +        (DESY+AACH+HAMB+SIEG+WUPP)
BACINO1   79 PRL 42 6           +FERGUSON,NODULMAN +    (UCLA+SLAC+UCI+STON)
BACINO2   79 PRL 42 749         +FERGUSON,NODULMAN+     (UCLA+SLAC+UCI+STON)

                                REVIEWS

PERL2     77 HAMBURG SYMP.      ALSO ISSUED AS SLAC-PUB-2022, M.PERL (SLAC)
FLUGGE    77 MESON CONF.BOSTON  ALSO ISSUED AS DESY 77-35, G.FLUGGE  (DESY)

AZIMOV    78 SPU 21 225         +FRANKFURT,KHOZE                        (LENI)
FELDMAN   78 SLAC-PUB-2224      G.J.FELDMAN (TOKYO CONF.1978)           (SLAC)
PERL      78 SLAC-PUB-2219      M.L.PERL (KARLSRUHE SUMMER INST.1978)(SLAC)

FLUGGE    79 ZP C1 121          G.FLUGGE                                (DESY)
KIRKBY    79 SLAC-PUB-2419      J.KIRKBY                                (SLAC)
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                     8  CHARGED PION(140,JPG=0--) I=1

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                     8  CHARGED PION MASS (MEV)

M              139.37      0.20            CROWE     54 CNTR  -
M              139.68      0.15            BARKAS    56 EMUL +
M    S        (139.577)   (0.013)          SHAFER    67 CNTR  - MESONIC ATOMS     6/68
M    B        (139.549)   (0.008)          BACKENSTO 71 CNTR  - MESONIC ATOMS    10/71
M     S        139.566     0.013           SHAFER    72 CNTR  - MESONIC ATOMS     1/73
M     B        139.569     0.008           BACKENSTO 73 CNTR  - MESONIC ATOMS     1/73
M              139.571     0.010           BRANDAODO 76 CNTR  - MESONIC ATOMS     1/78
M              139.5686    0.0020          CARTER    76 CNTR  - MESONIC ATOMS     6/77
M     M        139.5667    0.0024          MARUSHENK 76 CNTR  - MESONIC ATOMS    12/77
M    D        (139.5652)  (0.0019)         DAUM      78 SPEC +  PI+ --> MU+ NEU   2/78
M     S   SHAFER 72 UPDATES SHAFER67 WITH NEW ALPHA AND NEW CALIB. LINE ENER.  1/73
M     B   BACKENSTOSS 73 CORRECTS BACKENSTOSS 71 WITH NEW VACUUM POL. CALC.    1/73
M     M   THIS MARUSHENKO 76 VALUE USED AT AUTHORS REQUEST BECAUSE IT USES     3/78
M     M   ACCEPTED SET OF CALIBRATION GAMMA ENERGIES.  ERROR INCREASED FROM    3/78
M     M   .0017 TO INCLUDE QED CALC. ERROR OF .0017 (12 PPM).                  3/78
M    D    DAUM 78 VALUE DEPENDS ON ASSUMED MU+ MASS M(MU)=105.65948+-.00035 .  2/78
M    D    ENTERS OUR FIT VIA PI-MU MASS DIFF. BELOW WHICH IS INDEP. OF M(MU).  2/78
M            . . . . . . . . . . .
M    AVG       139.5679    0.0015   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    STUDENT   139.5679    0.0016   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M    FIT       139.5669    0.0012  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*

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                8  (PI+) - (MU+) MASS DIFFERENCE (MEV)

D              34.00     0.076              BARKAS    56 EMUL
D              33.89     0.076              BARKAS    56 EMUL
D        145   33.881    0.035              HYMAN     67 HEBC  + K-HE              2/71
D              33.925    0.025              BOOTH     70 CNTR  + MAGNETIC SPECT.   2/71
D              33.9057   0.0019             DAUM      78 SPEC +  SEE NOTE D ABOVE  2/78
D                 . . . . . . . . .
D    AVG       33.9058   0.0019  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D    STUDENT   33.9058   0.0020  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
D    FIT       33.9074   0.0012 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*
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                8  ((PI+) - (PI-))/AVG., MASS DIFFERENCE (PERCENT)

DM              0.02     0.05               AYRES     71 CNTR                      3/71
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                8  CHARGED PION MEAN LIFE (UNITS 10**-9)

T              25.6      0.5      0.5   CROWE     57 RVUE
T              25.6      0.8      0.8   ANDERSON  60 CNTR
T       8000   25.46     0.32     0.32  ASHKIN    60 CNTR +
T              26.02     0.04           ECKHAUSE  65 CNTR +                        9/66
T              25.6      0.3            BARDON    66 CNTR                          6/66
T              25.9      0.3            DUNAITSEV 66 CNTR                          6/68
T   N         (26.40)   (0.08)          KINSEY    66 CNTR +                        6/66
T   N    SYSTEMATIC ERRORS IN CALIBR.IN THIS EXP.DISCUSSED BY NORDBERG 67          8/67
T              26.67     0.24           LOBKOWICZ 66 CNTR                          9/66
T              26.04     0.05           NORDBERG  67 CNTR +                        8/67
T              26.02     0.04           AYRES     71 CNTR +-                       3/71
T              26.09     0.08           DUNAITSEV 73 CNTR +                        3/74
T                 . . . . . . . . .
T   AVG        26.030    0.023    0.023  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T   STUDENT    26.028    0.025    0.025  AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
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                8  ((PI+) - (PI-))/AVG., MEAN LIFE DIFF. (PERCENT)

DT  N   THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W.I.

DT              0.23     0.40               LOBKOWICZ 66 CNTR     SEE NOTE L       9/66
DT  L    ABOVE IS THE MOST CONSERVATIVE VALUE QUOTED BY AUTHORS                    9/66
DT              0.4      0.7                BARDON    66 CNTR                      7/66
DT             -0.14     0.29               PETRUKHIN 68 CNTR                      8/68
DT              0.055    0.071              AYRES     71 CNTR                      3/71
DT                . . . . . . . . .
DT  AVG         0.053    0.068   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
DT  STUDENT     0.053    0.073   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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                8  CHARGED PION PARTIAL DECAY MODES

                                                                 DECAY MASSES
P1      CHAR. PION INTO MU (MU-NEU)                              105+   0
P2      CHAR. PION INTO E ( E-NEU)                                .5+   0
P3      CHAR. PION INTO MU (MU-NEU) GAMMA                        105+   0+    0
P4      CHAR. PION INTO PIO E (E-NEU)                            134+  .5+    0
P5      CHAR. PION INTO E NEU GAMMA                               .5+   0+    0
P6      CHAR. PION INTO E NEU E+ E-                               .5+   0+   .5+   .5
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                8  CHARGED PION BRANCHING RATIOS

R1      CHAR. PION INTO MU NEU GAMMA (UNITS 10**-4)         (P3)/(P1)
R1        26     1.24     0.25              CASTAGNOL 58 EMUL      E(MU).LT.3.38 MV

R2      CHAR. PION INTO E NEU (UNITS 10**-4)                (P2)/(P1)
R2               1.21     0.07              ANDERSON  60 CNTR
R2  D           (1.247)  (0.028)            DI CAPUA  64 CNTR                     11/75
R2 D             1.274    0.024             BRYMAN    75 RVUE                      9/75
R2 D    BRYMAN 75 IS A RECALC. OF DICAPUA 64 EXPT USING LATEST PI LIFETIME.        9/75
R2                . . . . . . . . .
R2  AVG          1.267    0.023    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  STUDENT      1.268    0.025    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R3      CHAR. PION INTO PIO E NEU (UNITS 10**-8)            (P4)/(P1)
R3  D    52    (1.15)    (.22)              DEPOMMI1  63 CNTR +                    2/72
R3    D  36     0.97      0.20              BARTLETT  64 OSPK +
R3    D  38     1.07      0.21              BACASTOW  65 OSPK +
R3    D         1.10      0.26              BERTRAM   65 OSPK +                    6/66
R3    D  43     1.1       0.2               DUNAITSEV 65 CNTR +                    7/66
R3      332     1.00      0.08      0.10    DEPOMMIER 68 CNTR +                    3/68
R3                . . . . . . . . .
R3  AVG         1.023     0.069    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  STUDENT     1.023     0.074    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
    D    DEPOMMIER 68 STATES THAT THE RESULT OF DEPOMMIER 63 IS AT LEAST           2/72
    D    10 PERCENT TOO LARGE BECAUSE OF A SYSTEMATIC ERROR IN THE PIO             2/72
    D    DETECTION EFFICIENCY.  THIS MAY BE TRUE OF ALL THE PREVIOUS               2/72
    D    MEASUREMENTS ACCORDING TO DEPOMMIER 68 AND V.SOERGEL, PRIVATE             2/72
    D    COMMUNICATION, 1972.

R4      CHAR. PION INTO E NEU GAMMA (UNITS 10**-8)          (P5)/(P1)
R4   E 143    (2.15)     (0.5)              DEPOMMI2  63 CNTR + GAM KE 50-90 MEV  12/77
R4   S 226     5.6        0.7               STETZ     78 SPEC + E MOM >56 MEV/C.  12/79*
R4   E   DEPOMMIER 63 VALUE IS CORRECTED FOR THE LATEST VALUE OF THE PIO          12/77
R4   E   LIFETIME (0.828+-0.057 E-16). SEE FOOTNOTE 10 OF DEPOMMIER 77.           12/77
R4   S   STETZ 78 IS FOR E-GAMMA OPENING ANGLE >132DEG.  OBTAINS 3.7 WHEN         12/79*
R4   S   USING SAME CUTOFFS AS DEPOMMIER.                                         12/79*

R5      CHAR. PION INTO E NEU E+ E- (UNITS 10**-8)          (P6)/(P1)
R5             3.4   OR LESS  CL=.90    KORENCHEN 71 OSPK +                       10/71
R5             0.48  OR LESS  CL=.90    KORENCHEN 76 SPEC +                        1/78
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REFERENCES FOR CHARGED PION


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CROWE     54 PR  96  470        K M CROWE,R H PHILLIPS                    (LRL)
BARKAS    56 PR 101  778        W H BARKAS,W BIRNBAUM,F M SMITH           (LRL)
CROWE     57 NC   5  541        K M CROWE                      (STANFORD HEPL)
CASTAGNO  58 PR 112 1779        C CASTAGNOLI,M MUCHNIK                   (ROMA)

ANDERSON  60 PR 119 2050        H L ANDERSON,T FUJII,R H MILLER +         (EFI)
ASHKIN    60 NC  16  490        ASHKIN,FAZZINI,FIDECARO,LIPMAN +         (CERN)
DEPOMMI1  63 PL   5 61          DEPOMMIER,HEINTZE,RUBBIA,SOERGEL         (CERN)
DEPOMMI2  63 PL   7 285         P DEPOMMIER,HEINTZE,RUBBIA,SOERGEL       (CERN)
   ALSO   77 PRL 39 1113        DEPOMMIER,MARTIN+(MONT+BRCO+TRIU+VICT+MELB)
BARTLETT  64 PR 136B 1452       BARTLETT,DEVONS,MEYER,ROSEN          (COLUMBIA)
DI CAPUA  64 PR 133B 1333       DI CAPUA,GARLAND,PONDROM,STRELZOFF       (COLU)

BACASTOW 65 PR 139 B407         +GHESQUIERE,WIEGAND,LARSEN          (LRL+SLAC)
BERTRAM  65 PR 139 B 617        BERTRAM,MEYER,CARRIGAN+     (MICH+CARNEGIE)
DUNAITSE 65 JETP 20 58          DUNAITSEV,PETRUKHIN,PROKOSHKIN +      (DUBNA)
ECKHAUSE 65 PL 19 348           ECKHAUSE,HARRIS,SHULER+ (WILLIAM AND MARY)

BARDON   66 PRL 16 775          BARDON,DORE,DORFAN,KRIEGER +       (COLUMBIA)
DUNAITSE 66 PL 23 283           +KUTYIN,PROKOSHKIN,RASUVAEV,SIMONOV (DUBNA)
KINSEY   66 PR 144   1132       KINSEY,LOBKOWICZ,NORDBERG (ROCHESTER UNIV)
LOBKOWIC 66 PRL  17  548        LOBKOWICZ,MELISSINOS,NAGASHIMA+ (ROCH+BNL)

HYMAN    67 PL 25B 376          +LOKEN,PEWITT,DERRICK +     (ANL+CARN+NWES)
NORDBERG 67 PL 24B  594         NORDBERG,LOBKOWICZ,BURMAN (ROCHESTER UNIV)
SHAFER   67 PR 163 1451         ROBERT E. SHAFER                        (LRL)
   ALSO 65 PRL 14 923           SHAFER,CROWE,JENKINS                    (LRL)

DEPOMMIE 68 NP 84 189           DEPOMMIER,DUCLOS,HEINTZE,KLEINKNECHT+(CERN)
PETRUKHI 68 JINR-P1-3862        PETRUKHIN,RYKALIN,KHAZINS,CISEK      (DUBNA)
BOOTH    70 PL 32B 723          +JOHNSON,WILLIAMS,WORMALD             (LIVP)
AYRES    71 PR 3D 1051          +CORMACK,GREENBERG,KENNEY +     (LRL,UCSB)
   ALSO 67 PR   157  1288       AYRES,CALDWELL,GREENBERG,KENNEY,KURZ+ (LRL)
   ALSO 68 PRL 21 261           AYRES,CORMACK,GREENBERG,KENNEY+ (LRL,UCSB)
   ALSO 69 UCRL-18369           DAVID S AYRES (THESIS)                  (LRL)
   ALSO 69 PRL 23 1267          GREENBERG,AYRES,CORMACK,KENNEY+ (LRL,UCSB)

BACKENST 71 PL 36B 403          BACKENSTOSS,DANIEL,KOCH+   (CERN,KARL,HEID)
   ALSO 70 THESIS               C. VON DER MALSBURG            (HEIDELBERG)
KORENCHE 71 SJNP 13 189         KORENCHENKO,KOSTIN,MICELMACHER+       (JINR)
SHAFER   72 PRIVATE COMM.       R. SHAFER, 1972                       (FNAL)
BACKENST 73 PL 43B 539          BACKENSTOSS,DANIEL,KOCH+ (CERN+KARL+MUNICH)
   ALSO 73 SUBMITTED TO NP      L. TAUSCHER
DUNAITSE 73 SJNP 16 292         DUNAITSEV,PROKOSHKIN,RAZUVAEV+        (SERP)

BRYMAN   75 PR D11 1337         +PICCIOTTO              (UNIV OF VICTORIA)
BRANDAO  76 ZNAT 31A 1150       BRANDAO D'OLIVERA,DANIEL,VON EGIDY+  (MUNC)
CARTER   76 PRL 37 1380         +DIXIT,SUNDARESAN+       (CARL+CNRC+CHIC+CIT)
KORENCHE 76 JETP 44 35          KORENCHENKO,KOSTIN,MICELMACHER+       (JINR)
MARUSHEN 76 JETPL 23 72         MARUSHENKO,MEZENTSEV,PETRUNIN+        (LENI)
   ALSO 76  PRIVATE COMM.       R. SHAFER                             (FNAL)
   ALSO 78  PRIVATE COMM.       A. I. SMIRNOV                         (LENI)
DAUM     78 PL 74B 126          +EATON,FROSCH,HIRSCHMANN,MCCULLOCH+    (SIN)
STETZ    78 NP B138 285         +CARROLL,ORTENDAHL,PEREZ-MENDEZ+ (LBL+UCLA)

                               PAPERS NOT REFERRED TO IN DATA CARDS

CARTWRIG 53 PR 91 677           CARTWRIGHT,RICHMAN,WHITEHEAD,WILCOX  (LRL)J
MERRISON 62 ADVP 11 1           A W MERRISON                     (LIVERPOOL)
SHAPIRO  62 PR 125 1022         G SHAPIRO,L M LEDERMAN            (COLUMBIA)
CZIRR    63 PR 130 341          JOHN B CZIRR                           (LRL)
CARRIGAN 68 NP B6 662           R.A.CARRIGAN JR.                    (CARN)J
WILKIN   80 JPG 6 L5            C. WILKIN                           (LOUC)P
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                9  NEUTRAL PION(135,JPG=0--) I=1
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                9  (PI+-) - (PIO) MASS DIFFERENCE (MEV)

D             (5.37)    (1.0)               PANOFSKY  51 CNTR  -
D              4.50      0.31               CHINOWSKY 54 CNTR  -
D              4.62      0.05               HADDOCK   59 CNTR  -
D              4.60      0.04               HILLMAN   59 CNTR
D              4.55      0.07               CASSELS   59 CNTR
D              4.69      0.07               SAMIOS    60 HBC                       2/72
D              4.6056    0.0055             CZIRR     63 CNTR
D              4.59      0.03               PETRUKHIN 63 CNTR  -
D              4.6034    0.0052             VASILEVSK 66 CNTR  -                   9/66
D                 . . . . . . . . .
D    AVG       4.6043    0.0037  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D    STUDENT   4.6043    0.0040  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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                9  NEUTRAL PION MEAN LIFE (UNITS 10**-16)

T   N   76    (1.9)     (0.5)     (0.5)  GLASSER   61 EMUL
T   N   45    (2.3)     (1.1)     (1.0)  TIETGE    62 EMUL
T   N   88    (2.8)     (0.9)     (0.9)  KOLLER    63 EMUL     SEE STAMER 66
T              1.05      0.18      0.18  VON DARDE 63 CNTR
T   N   75    (1.7)     (0.5)            SHWE      64 EMUL
T              0.730     0.105           BELLETTIN 65 CNTR                         6/66
T   N   67    (1.6)     (0.6)     (0.5)  EVANS     65 EMUL                         6/66
T   K  232     1.0       0.5             STAMER    66 EMUL                         8/67
T              0.56      0.06            BELLETTIN 70 CNTR     PRIM.EFF. CN NUC    7/70
T              0.9       0.068           KRYSHKIN  70 CNTR     PRIMAKOFF EFFECT   12/70
T   B          0.82      0.04            BROWMAN   74 CNTR     PRIMAKOFF EFFECT    7/75
T     N   OLD EMULSION MEASUREMENTS NOT USED BECAUSE OF POSSIBLE SYSTEMATIC
T     N   SHIFT TO LARGER MEAN LIFE VALUES.
T     K   INCLUDES EVENTS OF KOLLER 63.                                            8/67
T     B   BROWMAN GIVES PIO WIDTH=8.02+-.42EV.  MEAN LIFE IS HBAR/WIDTH.          11/75
T                 . . . . . . . . .
T    AVG       0.828     0.057     0.053  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.8)
T    STUDENT   0.835     0.038     0.035  AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
                                   (SEE IDEOGRAM BELOW)
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                9  NEUTRAL PION PARTIAL DECAY MODES

                                                                DECAY MASSES
P1      PIO INTO 2GAMMA                                          0+    0
P2      PIO INTO E+ E- GAMMA                                    .5+   .5+    0
P3      PIO INTO 4ELECTRONS                                     .5+   .5+   .5+   .5
P4      PIO INTO 3 GAMMA                                         0+    0+    0
P5      PIO INTO 4 GAMMA                                         0+    0+    0+    0
P6      PIO INTO E+ E-                                          .5+   .5
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                9  NEUTRAL PION BRANCHING RATIOS

R1      PIO INTO (GAMMA E+ E-)/(2GAMMA) (PERCENT)             (P2)/(P1)
R1            (1.196)  THEORET. CALC.  JOSEPH     60        QUANTUM ELECT.      9/66
R1      27     1.17      0.15            BUDAGOV   60 HBC
R1    3071     1.166     0.047           SAMIOS    61 HBC     PI-P TO PIO N.
R1  S    SAMIOS VALUE USES PANOFSKY RATIO = 1.62
R1                . . . . . . . . .
R1   AVG       1.166     0.045   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1   STUDENT   1.166     0.048   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

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R2      PIO INTO (3 GAMMA)/TOTAL       (UNITS 10**-6)        (P4)
R2   D   0     4.9   OR LESS  CL=.90    DUCLOS     65 CNTR                        6/66
R2   D         4.9   OR LESS  CL=.90    KUTIN      65 CNTR                        3/68
R2   D  THESE EXPTS. GIVE BR(3GAMMA/2GAMMA)<5.0*10**-6.
R2       0     1.5   OR LESS  CL=.90    AUERBAC1   78 CNTR                        1/79*

R3      PIO INTO (E+E+E-E-)/(2 GAMMA) (UNITS 10**-5)         (P3)/(P1)
R3      146    3.18      0.30           SAMIOS     62 HBC        SEE NOTE N BELOW  6/66
R3             3.28     THEORET. CALC.  MIYAZAKI   73            QUANTUM ELECT.    2/76
R3   N  ABOVE VALUE USES PANOFSKY RATIO = 1.62

R4      PIO INTO (4 GAMMA)/TOTAL         (UNITS 10**-5)      (P5)                 8/73
R4   A   0     6.0   OR LESS  CL=.90    ABRAMS     73 ASPK                        8/73
R4   A  ABRAMS 73 GIVES BR(4GAMMA/2GAMMA)<6.1*10**-5.
R4       0     3.8   OR LESS  CL=.90    AUERBAC2   78 CNTR                        2/79*

R5      PIO INTO (E+ E-)/TOTAL   (UNITS 10**-6)              (P6)/(P1)           12/75
R5   D         2.0   OR LESS  CL=.90    DAVIES     74 RVUE                       12/75
R5       8     0.223     0.240    0.110 FISCHER2   78 SPRK       K+ EXPT. CL=.90   6/78*
R5   D  DAVIES 74 EXTRACTS THIS INFORMATION FROM BLOCH 75 K+ EXPERIMENT.         12/75
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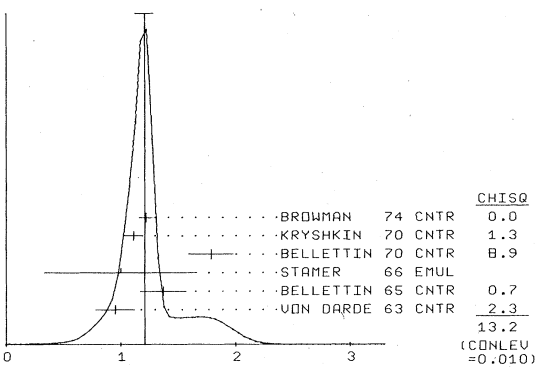
WEIGHTED AVERAGE = 1.207 ± 0.080
ERROR SCALED BY 1.8



9 NEUTRAL PION ELECTROMAGNETIC FORM FACTOR

THE AMPLITUDE FOR THE PROCESS PIO --> E+ E- GAMMA CONTAINS A FORM FACTOR GAMMA(X**2) AT THE (PIO GAMMA GAMMA) VERTEX WHERE X=MASS(E+E-)/MASS(PIO). THE PARAMETER A IN THE LINEAR EXPANSION GAMMA(X**2)=1+A*(X**2) IS LISTED BELOW.

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A       LINEAR COEFFICIENT OF PIO ELECTROMAGNETIC FORM FACTOR
A              (-0.15)   (0.10)           KOBRAK    61 HBC     NO RAD. CORR.     2/80*
A       3071   (-0.24)   (0.16)           SAMIOS    61 HBC     NO RAD. CORR.     2/80*
A       2200   (+0.01)   (0.11)           DEVONS    69 OSPK    NO RAD. CORR.     2/80*
A     F 30K    +0.10      0.03            FISCHER1  78 SPEC    RAD. CORR.        2/80*
A     F  ERROR STATISTICAL ONLY.  RESULT WITHOUT RAD. CORR.=+0.05+-0.03.         2/80*
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REFERENCES FOR NEUTRAL PION


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PANOFSKY 51 PR    81  565        W K H PANOFSKY,R L AAMODT,J HADLEY     (LRL)
CHINOWSK 54 PR    93  586        W CHINOWSKY,J STEINBERGER          (COLUMBIA)
CASSELS  59 PPS  74    92        CASSELS,JONES,MURPHY,O.NEILL      (LIVERPOOL)
HADDOCK  59 PRL    3  478        HADDOCK,ABASHIAN,CROWE,CZIRR             (LRL)
HILLMAN  59 NC    14  887        HILLMAN,MIDDELKOOP,YAMAGATA,ZAVATTINI(CERN)

BUDAGOV  60 JETP 11  755         BUDAGOV,VIKTOR,DZHELEPOV,ERMOLOV +    (JINR)
JOSEPH   60 NC 16 997            D W JOSEPH                              (EFI)
SAMIOS   60 NC 18 154            N P SAMIOS                         (COLUMBIA)
GLASSER  61 PR  123 1014         R G GLASSER,N SEEMAN,B STILLER          (NRL)
KOBRAK   61 NC 20 1115           H.KOBRAK                                (EFI)
SAMIOS   61 PR  121  275         N P SAMIOS                     (COLUMBIA+BNL)
SAMIOS   62 PR 126 1844          SAMIOS,PLANO,PRODELL +         (COLUMBIA+BNL)
TIETGE   62 PR  127 1324         J TIETGE,W PUESCHEL         (MAX PLANCK INST)

CZIRR    63 PR  130  341         JOHN B CZIRR                            (LRL)
KOLLER   63 NC   27 1405         E L KOLLER,S TAYLOR,T HUETTER       (STEVENS)
    ALSO 66 STAMER
PETRUKHI 63 SIENA CONF 208       V I PETRUKHIN,YU D PROKOSHKIN          (JINR)
VON DARD 63 PL    4   51         VON DARDEL,DEKKERS,MERMOD,VAN PUTTEN+(CERN)

SHWE     64 PR  136B 1839        H SHWE,F M SMITH,W H BARKAS             (LRL)
BELLETTI 65 NC 40 A 1139         BELLETTINI,BEMPORAD,BRACCINI+(PISA+FIRENZE)
DUCLOS   65 PL 19 253            DUCLOS,FREYTAG,HEINTZE +  (CERN+HEIDELBERG)
EVANS    65 PR 139 B 982         D A EVANS                            (OXFORD)
KUTIN    65 JETP LETT 2 243      KUTIN,PETRUKHIN,PROKOSHKIN             (JINR)

STAMER   66 PR 151  1108         STAMER,TAYLOR,KOLLER,HUETTER+       (STEVENS)
VASILEVS 66 PL   23  281         VASILEVSKY,VISHNYAKOV,DUNAITSEV +     (DUBNA)
DEVONS   69 PR 184 1356          +NEMENTHY,NISSIM-SABAT,DI CAPUA+(COLU+ROMA)
BELLETTI 70 NC 66A 243           BELLETTINI,BEMPORAD,LUBELSMEY+  (PISA+BONN)
KRYSHKIN 70 JETP 30 1037         +STERLIGOV,USOV         (TOMSK POLYTECH.INST.)

ABRAMS   73 PL 45B 66            +CARROLL,KYCIA,LI,MICHAEL,MOCKETT +     (BNL)
MIYAZAKI 73 PR D8 2051           T.MIYAZAKI,E.TAKASUGI                  (TOKY)
BROWMAN  74 PRL 33 1400          +DEWIRE,GITTELMAN,HANSON+         (CORN+BING)
DAVIES   74 NC 24A 324           +GUY,ZIA                     (BIRM+RHEL+SHMP)

AUERBAC1 78 PRL  41  275         +AUERBACH,HIGHLAND,JOHNSON, +     (TEMP+LASL)
AUERBAC2 78 PL  78B  353         +AUERBACH,HIGHLAND,JOHNSON, +     (TEMP+LASL)
FISCHER1 78 PL  73B  359         +EXTERMANN,GUISAN,MERMOD,+        (GEVA+SACL)
FISCHER2 78 PL  73B  364         +EXTERMANN,GUISAN,MERMOD,MOREL+   (GEVA+SACL)
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14 ETA(549,JPG=0-+) I=0

14 ETA MASS (MEV)

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M        53  549.0       1.2               BASTIEN   62 HBC
M        35  546.0       4.0               PICKUP    62 HBC
M        91  548.0       1.0               ALFF      62 HBC
M            549.3       2.9               DELCOURT  63 CNTR
M       148  549.0       0.7               FOELSCHE  64 HBC
M       325  552.0       3.0               KRAEMER   64 DBC
M            548.2       0.65              FOSTER3   65 HBC                   7/66
M       250  555.0       2.0               JAMES     66 HBC                   6/66
M             . . . . . . . . .
M   AVG      548.82      0.56     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
M   STUDENT  548.72      0.44     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                         (SEE IDEOGRAM BELOW )
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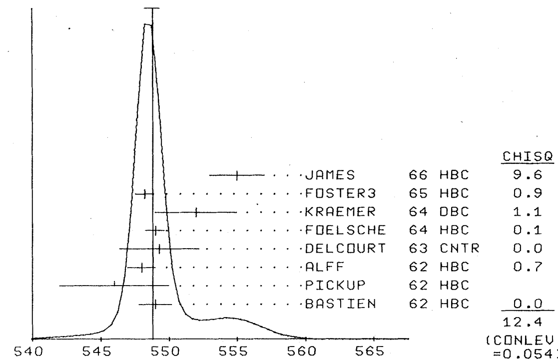
WEIGHTED AVERAGE = 548.82 ± 0.56
ERROR SCALED BY 1.4



14 ETA WIDTH

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W      ETA WIDTH DETERMINED FROM MASS SPECTRUM (UNITS MEV)
W       91  (10.0)  OR LESS                ALFF      62 HBC
W      148  (10.0)  OR LESS                FOELSCHE  64 HBC
W       31  (12.0)  OR LESS                JAMES     66 HBC                   6/66
W            (4.0)  OR LESS                BALTAY    66 DBC                   7/66
W             (.9)  OR LESS  CL=.95        JONES     66 CNTR                  8/67

W      ETA WIDTH DETERMINED FROM DECAY RATE (UNITS KEV)
W       THIS IS THE PARTIAL DECAY RATE (W1) FOR THE MODE (ETA INTO 2GAMMA)
W       DIVIDED BY THE FITTED BRANCHING FRACTION (P1) FOR THAT MODE.
W            . . . . . . . . .
W   FIT       0.85       0.12    FROM FIT
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14 ETA PARTIAL DECAY MODES

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                                                          DECAY MASSES
P1     ETA INTO 2GAMMA                                     0+    0
P2     ETA INTO 3PIO                                     134+ 134+ 134
P3     ETA INTO PI+ PI- PIO                              139+ 139+ 134
P4     ETA INTO PI+ PI- GAMMA                            139+ 139+   0
P5     ETA INTO E+ E- PIO (VIOLATES C IN E.M.I.)         134+  .5+  .5
P6     ETA INTO E+ E- PI+ PI-                            139+ 139+  .5+  .5
P7     ETA INTO PIO 2GAMMA                               134+   0+   0
P8     ETA INTO E+ E- GAMMA                               .5+  .5+   0
P9     ETA INTO 2PIO GAMMA (VIOLATES C)                  134+ 134+   0
P10    ETA INTO PI+ PI- PIO GAMMA                        139+ 139+ 134+   0
P11    ETA INTO PI+ PI- 2GAMMA                           139+ 139+   0+   0
P12    ETA INTO MU+ MU-                                  105+ 105
P13    ETA INTO MU+ MU- GAMMA                            105+ 105+   0
P14    ETA INTO MU+ MU- PIO                              105+ 105+ 134
P15    ETA INTO PI+ PI-                                  139+ 139
P16    ETA INTO E+ E-                                     .5+  .5
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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 7	P 8
P 1	.3799+-.0098					
P 2	-.2691	.2990+-.0106				
P 3	-.3224	-.2353	.2358+-.0056			
P 4	-.2866	-.2095	.8201	.0489+-.0013		
P 7	-.4271	-.5781	-.0939	-.0801	.0314+-.0109	
P 8	-.0434	-.0326	-.0494	-.0501	-.0036	.0050+-.0012

Stable Particles

η

Data Card Listings

For notation, see key at front of Listings.

FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e., $G_i \equiv \Gamma_i = \Gamma_{total}P_i$, in appropriate units. In analogy to the matrix above, the diagonal elements are $G_i \pm \delta G_i$, where $\delta G_i = \sqrt{\langle \delta G_i \delta G_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta G_i \delta G_j \rangle / (\delta G_i \cdot \delta G_j)$. Note that, because of the error in Γ_{total}, the errors and correlations here are not directly derivable from those above.

```
        G 1          G 2          G 3          G 4          G 7          G 8
G 1 .3240+-.C460
G 2   .9386    .2550+-.0385
G 3   .9689     .9513   .2011+-.0294
G 4   .9646     .9471    1.0097   .0417+-.0061
G 7   .3661     .3028     .4240     .4226   .0268+-.0104
G 8   .5178     .5C82     .5233     .5199     .2318   .0043+-.0012
```

14 ETA DECAY RATES

```
W1     ETA INTO 2GAMMA (UNITS KEV)                          (G1)
W1  B      (1.00)   (0.22)           BEMPORAD  67 CNTR    PRIMAKOFF EFFECT 11/75
W1          0.324    0.046           BROWMAN   74 CNTR    PRIMAKOFF EFFECT  7/74
W1  B   BEMPORAD 67 GIVES W1=1.21+-.26 KEV ASSUMING THAT W1/TOTAL=0.314.    11/75
W1  B   BEMPORAD PRIVATE COMMUNICATION GIVES MORE GENERAL RESULT AS         11/75
W1  B   W1*W1/TOTAL=.380+-.083.  WE EVALUATE THIS USING W1/TOTAL=.38+-.01.  11/75
W1  B   NOT INCLUDED IN AVERAGE BECAUSE THE UNCERTIANTY RESULTING FROM THE   2/76
W1  B   SEPARATION OF THE COULOMB AND NUCLEAR AMPLITUDES HAS APPARENTLY      2/76
W1  B   BEEN UNDERESTIMATED.                                                 2/76
W1              . . . . . . . . .
W1  FIT     0.324     0.046   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
```

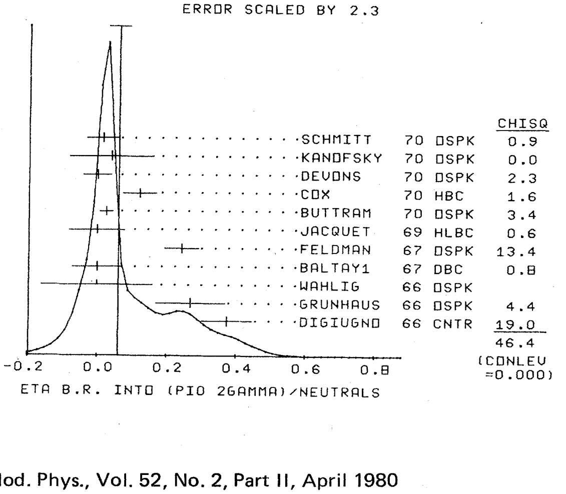
14 ETA BRANCHING RATIOS

```
R1     ETA INTO NEUTRALS/CHARGED                       (P1+P2+P7)/(P3+P4+P8)
R1  N   10    (2.5)     (1.0)          PICKUP     62 HBC
R1  N   53    (3.20)    (1.26)         BASTIEN    62 HBC
R1  N         (2.7)     (0.8)          SHAFER     62 HBC
R1             2.6        .9           BUSCHBECK  63 HBC                     7/66
R1  N  280    (4.5)     (1.0)          JAMES      66 HBC                     6/66
R1  N   THESE EXPERIMENTS HAVE NOT BEEN USED IN COMPUTING THE AVERAGES
R1  N   AS THEY WERE UNABLE TO SEPARATE CLEARLY PARTIAL MODES (3) AND (4)
R1  N   FROM EACH OTHER.  THE REPORTED VALUES THUS PROBABLY CONTAIN
R1  N   SOME (UNKNOWN) FRACTION OF MODE (4).
R1             2.64      0.23          BALTAY2    67 DBC                    11/67
R1            . . . . . . . . .
R1  AVG        2.64      0.22    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT    2.64      0.24    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT        2.452     0.081  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R2     ETA INTO 2GAMMA/CHARGED                              (P1)/(P3+P4+P8)
R2             0.99      0.48          CRAWFORD   63 HBC
R2            . . . . . . . . .
R2  FIT        1.311     0.053  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
```

Note on $\eta \to \pi^0\gamma\gamma$

The discrepancies between various measurements of branching ratios involving $\eta \to \pi^0\gamma\gamma$ are displayed in the ideogram below, in which all relevant experiments have been converted to a common ratio, $\pi^0\gamma\gamma$/neutrals. Our branching ratio fit does not include DIGIUGNO 66, FELDMAN 67, or the upper limit measurements. See page 43 of "Review of Particle Properties", Physics Letters 39B, No. 1 (1972) for more discussion.

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R3     ETA INTO (PIO 2GAMMA)/NEUTRALS                           (P7)/(P1+P2+P7)
R3  S      (0.375)  (0.072)          DIGIUGNO  66 CNTR    ERROR DOUBLED      6/66
R3     THE ERRORS OF DIGIUGNO+ 66 HAVE BEEN INCREASED BY A FACTOR
R3     OF TWO, TO TAKE INTO ACCOUNT POSSIBLE SYSTEMATIC ERRORS, AS
R3     SUGGESTED BY THE AUTHORS.
R3          .27       .10            GRUNHAUS  66 OSPK                       8/67
R3  R      (.028)    (.044)          BUNIATOV  67 OSPK                      11/67
R3  S      (.244)    (.05)           FELDMAN   67 OSPK                       8/67
R3  S  SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.
R3          .026      .019           BUTTRAM   70 OSPK                      12/70
R3          .122      .052     .044  COX       70 HBC                        6/70
R3         (.07) OR LESS  CL=.90     DEVONS    70 OSPK                      12/70
R3 R    16  .016      .047           SCHMITT   70 OSPK                      12/70
R3 R   SCHMITT 70 IS A REANALYSIS BUNIATOV 67
R3  E      (0.11)   (0.03)           STRUGALSK 71 HLBC                       5/71
R3  E  THIS MEASUREMENT HAS BEEN EXCLUDED BECAUSE THE ERROR APPEARS           2/71
R3  E  TO BE SERIOUSLY UNDERESTIMATED.                                       2/71
R3          . . . . . . . . .
R3  AVG     0.042     0.023   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R3  STUDENT 0.039     0.019   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3  FIT     0.044     0.015  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R4     ETA INTO (PI+ PI- GAMMA)/(PI+ PI- PIO)                  (P4)/(P3)
R4          0.14      0.08           FOELSCHE  64 HBC
R4  M   24  (0.73)    (0.25)         PAULI     64 DBC
R4  M  THIS EXPERIMENT HAS NOT BEEN INCLUDED IN THE AVERAGES SINCE IT IS
R4  M  NOT CLEAR THAT THEIR CLASS B EVENTS ARE ACTUALLY FROM ETAS.
R4          0.30      0.06           CRAWFORD  66 HBC                        6/66
R4          .10       .10            KRAEMER   64 DBC                        7/66
R4          .196      .041           FOSTER3   65 HBC                        7/66
R4          .25       .035           LITCHFIEL 67 DBC                        8/67
R4          0.28      0.04           BALTAY2   67 DBC                       11/67
R4    7250  .201      .006           GORMLEY   70 ASPK                       6/70
R4     18K  0.209     0.004          THALER    73 ASPK                       6/73
R4          . . . . . . . . .
R4  AVG     0.2074    0.0037  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R4  STUDENT 0.2074    0.0037  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R4  FIT     0.2075    0.0033 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5     ETA INTO (3PIO) + 2/3(PIO 2GAMMA)/ PI+PI-PIO      (P2+2/3P7)/P3
R5          0.83      0.32           CRAWFORD  63 HBC                        7/66
R5          2.0       1.0            FOELSCHE  64 HBC                        7/66
R5          0.90      0.24           FOSTER1   65 HBC                        7/66
R5          . . . . . . . . .
R5  AVG     0.91      0.19    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  STUDENT 0.91      0.20    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R5  FIT     1.357     0.057  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R6     ETA INTO 3PIO/2GAMMA                                     (P2)/(P1)
R6         (.90) OR MORE             CHRETIEN  62 PBC
R6          0.88      0.16           BALTAY1   67 DBC                       11/67
R6          1.1       0.2            CENCE     67 OSPK                       1/68
R6          0.75      0.09           DEVONS    70 OSPK                      12/70
R6          . . . . . . . . .
R6  AVG     0.824     0.085   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R6  STUDENT 0.821     0.085   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R6  FIT     0.787     0.039  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                      (SEE IDEOGRAM BELOW )
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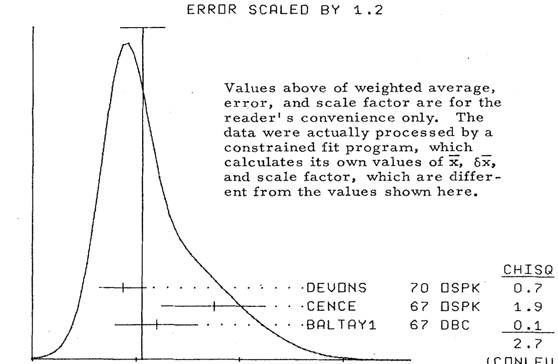


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R7     ETA INTO 2GAMMA/(PI+ PI- PO)                             (P1)/(P3)
R7          1.61      0.39           FOSTER1   65 HBC
R7     401  1.72      .25            BAGLIN    69 HLBC                       7/69
R7          . . . . . . . . .
R7  AVG     1.69      0.21    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R7  STUDENT 1.69      0.23    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R7  FIT     1.611     0.065  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R8     ETA INTO NEUTRAL/(PI+ PI- PIO)                     (P1+P2+P7)/(P3)
R8      50  3.6       0.8            KRAEMER   64 DBC
R8          3.8       1.1            PAULI     64 DBC                        7/66
R8          2.89      0.56           ALFF-STEI 66 HBC                        9/66
R8     244  3.6       0.6            FLATTE2   67 HBC                        1/68
R8      29  3.4       1.1            AGUILAR-B 72 HBC                       11/72
R8  B   70  2.83      0.80           BLOODWORT 72 HBC                       11/72
R8      74  2.54      1.89           KENDALL   74 OSPK                      12/75
R8  B  ERROR INCREASED FROM PUBLISHED VALUE 0.5 BY BLOODWORTH, PRIV. COMM.   1/73
R8          . . . . . . . . .
R8  AVG     3.26      0.30    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  STUDENT 3.26      0.33    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R8  FIT     3.01      0.10   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R9     ETA INTO (E+E-PIO)/(PI+PI-PIO) (UNITS 10**-4)    (P5)/(P3)
R9          110.      OR LESS        PRICE     65 HBC
R9      0   77.       OR LESS        FOSTER2   65 HBC
R9          42.       OR LESS  CL=.90  BAGLIN1   67 HLBC                     8/67
R9      0   16.       OR LESS  CL=.90  BILLING   67 HLBC                    11/67
R9          1.9       OR LESS  CL=.90  JANE1     75 OSPK                    12/75
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

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R10     ETA INTO (E+E-PI+PI-)/TOTAL (UNITS 10**-2)          (P6)
R10         (0.7)  OR LESS              RITTENBER 65 HBC                      6/66

R11     ETA INTO (E+E-PI+PI-)/(PI+PI-GAMMA)                 (P6)/(P4)
R11      1    0.026      0.026          GROSSMAN  66  HBC                     6/66

R12     ETA INTO 2 GAMMA/NEUTRALS                           (P1)/(P1+P2+P7)
R12 S        (0.416)   (0.044)          DIGIUGNO  66  CNTR    ERROR DOUBLED   6/66
R12           .44        .07            GRUNHAUS  66  OSPK                    8/67
R12 S        (.579)    (.052)           FELDMAN   67  OSPK                    8/67
R12 S   SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.
R12 T        (0.39)    (0.06)           JONES     66  CNTR                    8/67
R12 T   THIS RESULT FROM COMBINING CROSS SECTIONS FROM TWO DIFFERENT EXPTS.
R12           .59        .033           BUNIATOV  67  OSPK                   11/67
R12           .535       .018           BUTTRAM   70  OSPK                   12/70
R12           .486       .036           COX       70  HBC                     6/70
R12          0.57       0.09            STRUGALSK 71  HLBC                    5/71
R12     113  0.60       0.14            KENDALL   74  OSPK                   12/75
R12           . . . . . . . . .
R12 AVG      0.535      0.018     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R12 STUDENT  0.535      0.016     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R12 FIT      0.535      0.013     FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                                  (SEE IDEOGRAM BELOW )
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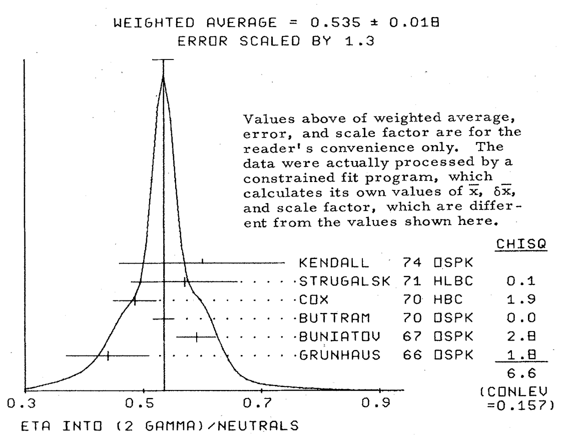


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R13     ETA INTO 3PI0/NEUTRALS                              (P2)/(P1+P2+P7)
R13 S        (0.209)   (0.054)          DIGIUGNO  66  CNTR    ERROR DOUBLED   6/66
R13 R        (.29)     (.10)            GRUNHAUS  66  OSPK                    8/67
R13 S        (.177)    (.035)           FELDMAN   67  OSPK                    8/67
R13 S   SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.
R13           .41        .033           BUNIATOV  67  OSPK                   11/67
R13 R   REDUNDANT INFORMATION FROM THIS EXPERIMENT.
R13 R        (.439)    (.024)           BUTTRAM   70  OSPK                   12/70
R13           .392       .042           COX       70  HBC                     6/70
R13          0.32       0.09            STRUGALSK 71  HLBC                    5/71
R13     75   0.40       0.14            KENDALL   74  OSPK                   12/75
R13           . . . . . . . . .
R13 AVG      0.397      0.025     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R13 STUDENT  0.397      0.027     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R13 FIT      0.421      0.014     FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R14     ETA INTO PI0 (2 GAMMA)/2GAMMA                       (P7)/(P1)
R14           (.5)  OR LESS  CL=.90     WAHLIG    66  SPRK                    7/66
R14          0.0        0.14            BALTAY1   67  DBC                    11/67
R14 P        (0.05)    (0.04)           BONAMY    67  SPRK  PRELIMINARY RESULT 11/67
R14           . . . . . . . . .
R14 FIT      0.083      0.030     FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R15     ETA INTO (E+E-PI0)/TOTAL (UNITS 10**-2)             (P5)
R15          0.7    OR LESS             RITTENBER 65  HBC                     6/66
R15          0.084  OR LESS  CL=.90     BAZIN     68  DBC                     6/68
R15      0   0.016  OR LESS  CL=.90     MARTYNOV  76  HLBC                    6/77

R16     ETA INTO 2GAMMA/(3PI0 + PI0 2GAMMA)                 (P1)/(P2+P7)
R16          0.83        .25            BACCI     63  CNTR                    7/66
R16           . . . . . . . . .
R16 FIT      1.150      0.060     FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R17     ETA INTO (PI+PI-PI0 GAMMA)/(PI+PI-PI0) (UNITS 10**-2)
R17                                                         (P10)/(P3)
R17          7.0    OR LESS             FLATTE    67  HBC                     8/67
R17          0.9    OR LESS             PRICE     67  HBC                     8/67
R17          1.6    OR LESS  CL=.95     BALTAY2   67  DBC                    11/67
R17          1.7    OR LESS  CL=.90     ARNOLD    68  HLBC                    9/68
R17      0   0.24   OR LESS  CL=.90     THALER    73  ASPK                    6/73

R18     ETA INTO (PI+PI- 2GAMMA)/(PI+PI-PI0)                (P11)/(P3)
R18          .009 OR LESS               PRICE     67  HBC                     8/67
R18          .016 OR LESS    CL=.95     BALTAY2   67  DBC                    11/67

R19     ETA INTO 3PI0/(PI+ PI- PI0)                         (P2)/(P3)
R19          1.3         .4             BAGLIN2   67  HLBC                    8/67
R19          1.47       0.20      0.17  BULLOCK   68  HLBC                    9/68
R19     199  1.50        .15       .29  BAGLIN    69  HLBC                    7/69
R19           . . . . . . . . .
R19 AVG      1.46       0.13      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R19 STUDENT  1.46       0.14      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R19 FIT      1.268      0.060     FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R20     ETA INTO 2GAMMA/((3PI0)+2/3(PI0 2GAMMA))            (P1)/(P2+2/3P7)
R20          1.10       0.5             MULLER    63  DBC                     7/66
R20           . . . . . . . . .
R20 FIT      1.187      0.058     FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R21     ETA INTO NEUTRALS/TOTAL                             (P1+P2+P7)
R21           .79        .08            BUNIATOV  67  OSPK                   11/67
R21     16K   .705       .008           BASILE    71  CNTR MM SPECTROMETER    8/71
R21           . . . . . . . . .
R21 AVG      0.7058     0.0080    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R21 STUDENT  0.7058     0.0086    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R21 FIT      0.7103     0.0068    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R22     ETA INTO (PI0 2GAMMA)/TOTAL                         (P7)
R22          .12  OR LESS  CL=.95       JACQUET   69  HLBC                    6/70
R22           . . . . . . . . .
R22 FIT      0.031      0.011     FROM FIT

R23     ETA INTO MU+MU-/TOTAL (UNITS 10**-5)                (P12)
R23      0    2.     OR LESS  CL=.95    WEHMANN   68  OSPK                    4/68

R24     ETA INTO MU+MU-PI0/TOTAL (UNITS 10**-4)             (P14)
R24           5.     OR LESS            WEHMANN   68  OSPK                    4/68

R25     ETA INTO MU+MU-/2GAMMA (UNITS 10**-5)               (P12)/(P1)
R25           5.9       2.2             HYAMS     69  OSPK                    7/69

R26     ETA INTO (PI0 2GAMMA)/(3PI0 + PI0 2GAMMA)           (P7)/(P2+P7)
R26 N         0.1       0.3             KANOFSKY  70  OSPK                    2/71
R26 N   WE HAVE CHANGED THE ERROR ON THIS EXPERIMENT FROM +0.3,-0.1           2/71
R26 N   TO THE ABOVE +0.3,-0.3 SINCE IT IS CLEAR FROM FIGURE 7 IN THE         2/71
R26 N   ARTICLE THAT A CENTRAL VALUE OF 0.0 IS ABOUT AS PROBABLE AS THE       2/71
R26 N   QUOTED VALUE OF 0.1.                                                  2/71
R26           . . . . . . . . .
R26 FIT      0.095      0.032     FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R27     ETA INTO (PI+ PI-)/TOTAL (UNITS 10**-2)             (P15)             6/73
R27      0   0.15  OR LESS              THALER    73  ASPK CON. LEV. NOT GIVEN 6/73

R28     ETA INTO (E+E-GAMMA)/(PI+PI-PI0) (UNITS 10**-2)  (P8)/(P3)
R28 J   80   2.1        0.5             JANE2     75  OSPK                    2/76
R28 J   VALUE CHANGED BY ERRATUM.                                             2/76
R28           . . . . . . . . .
R28 FIT      2.11       0.50      FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R29     ETA INTO (E+ E-)/TOTAL  (UNITS 10**-4)              (P16)
R29 D         3.    OR LESS  CL=.90     DAVIES    74  RVUE                    2/78
R29 D   DAVIES 74 EXTRACTS THIS INFORMATION FROM ESTEN 67.                    2/78

R30     ETA INTO (MU+ MU- GAMMA)/TOTAL   (UNITS 10**-4)  (P13)                2/79*
R30     100   1.5       0.75            BUSHNIN   78  SPEC                    2/79*
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14 ETA C-NONCONSERVING DECAY PARAMETERS

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        RELATED TEXT SECTION VI C.1

A1      LEFT-RIGHT ASYMMETRY PARAMETER FOR PI+ PI- PI0  (UNITS 10**-2)
A1      1351    7.2       2.8           BALTAY    66  DBC                     8/66
A1      1300    5.8       3.4           CLPWY     66  HBC                     8/66
A1     10665   (0.3)     (1.0)          CNOPS     66  OSPK REPL BY MULLER 69  8/67
A1       705   -6.1       4.0           LARRIBE   66  HBC                     8/67
A1    G36800   (1.5)     (.5)           GORMLEY3  68  ASPK                    6/68
A1     10709     .3       1.1           MULLER    69  OSPK                    9/69
A1      1138   -1.4       3.            CARPENTR  70  HBC                     6/70
A1       349    3.2       5.4           DANBURG   70  DBC                     2/71
A1      220K   -0.05      0.22          LAYTER    72  ASPK                    8/72
A1      165K    0.28      0.26          JANE1     74  OSPK                    3/74
A1 G    GORMLEY3 68 ASYMMETRY PROBABLY DUE TO UNMEASURED (E X B) SPK. CH.     3/74
A1 G    EFFECTS.  NEW EXPTS. WITH (E X B) CONTROLS DONT OBSERVE ASYMMETRY.    3/74
A1            . . . . . . . . .
A1 AVG          0.12      0.17     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A1 STUDENT      0.11      0.19     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

A2      LEFT-RIGHT ASYMMETRY PARAMETER FOR PI+ PI- GAMMA (UNITS 10**-2)
A2        33   -2.       17.            CRAWFORD  66  HBC                    11/66
A2             -4.        8.            LITCHFIEL 67  DBC                     8/67
A2 N    1620    1.5       2.5           MULLER    69  OSPK                    9/69
A2      7257    1.22      1.56          GORMLEY   70  ASPK                    6/70
A2       36K    0.5       0.6           THALER    72  ASPK                    8/72
A2       35K    1.2       0.6           JANE2     74  OSPK                    3/74
A2 N    MULLER 69 IS SENSITIVE ONLY TO UPPER .4 OF GAMMA-RAY SPECTRUM.
A2            . . . . . . . . .
A2 AVG          0.88      0.40     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A2 STUDENT      0.88      0.45     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

AS      SEXTANT ASYMMETRY PARAMETER FOR PI+ PI- PI0  (UNITS 10**-2)
AS      1300    6.8       3.3           CLPWY     66  HBC                    12/75
AS       705   -2.4       4.0           LARRIBE   66  HBC                    12/75
AS       37K    0.5       0.5           GORMLEY3  68  WIRE                   12/75
AS      220K    0.10      0.22          LAYTER    72  ASPK                   12/75
AS      165K    0.20      0.25          JANE1     74  OSPK                   12/75
AS            . . . . . . . . .
AS AVG          0.19      0.16     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AS STUDENT      0.19      0.17     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

AQ      QUADRANT ASYMMETRY PARAMETER FOR PI+ PI- PI0 (UNITS 10**-2)
AQ      220K   -0.07      0.22          LAYTER    72  ASPK                   12/75
AQ      165K   -0.30      0.25          JANE1     74  OSPK                   12/75
AQ            . . . . . . . . .
AQ AVG         -0.17      0.17     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AQ STUDENT     -0.17      0.18     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

BET     BETA FOR ETA TO PI+ PI- GAMMA. SENSITIVE TO D-WAVE CONTRIBUTION.
BET     DN/DCOS THETA = SIN**2 THETA * (1 + BETA * COS**2 THETA)             12/75
BET     7250   -0.060     0.065         GORMLEY   70  WIRE                   12/75
BET L           0.12      0.06          THALER    72  ASPK                   12/75
BET      35K    0.11      0.11          JANE2     74  OSPK                   12/75
BET L   AUTHORS DONT BELIEVE THIS TO INDICATE D-WAVE BECAUSE DEPENDENCE OF   12/75
BET L   BETA ON GAMMA ENERGY INCONSISTENT WITH THEOR. PREDICTION.            12/75
BET L   COS**2 DEPENDENCE MAY ALSO COME FROM P AND F-WAVE INTERFERENCE.      12/75
BET           . . . . . . . . .
BET AVG         0.047     0.062    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
BET STUDENT     0.053     0.053    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                   (SEE IDEOGRAM BELOW )
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14 ENERGY DEPENDENCE OF ETA DALITZ PLOT

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DP      RELATED TEXT SECTION VI C.2
DP      THE FOLLOWING EXPTS FIT TO ONE OR MORE OF THE COEFFICIENTS
DP      A,B,C,D, OR E FOR ETA TO PI+ PI- PI0
DP      MATRIX ELEMENT**2=1 + A*Y + B*(Y**2) + C*X + D*(X**2) + E*X*Y
DP      1300 SEE TEXT SEC VI C.2        CLPWY     66  HBC                    12/75
DP       705 SEE TEXT SEC VI C.2        LARRIBE   66  HBC                    12/75
DP      7170 SEE TEXT SEC VI C.2        CNOPS     68  OSPK                   12/75
DP       37K SEE TEXT SEC VI C.2        GORMLEY3  68  WIRE                   12/75
DP       526 SEE TEXT SEC VI C.2        BAGLIN    69  HLBC                   12/75
DP      1138 SEE TEXT SEC VI C.2        CARPENTR  70  HBC                    12/75
DP       349 SEE TEXT SEC VI C.2        DANBURG   70  DBC                    12/75
DP      7250 SEE TEXT SEC VI C.2        GORMLEY   70  WIRE                   12/75
DP      220K SEE TEXT SEC VI C.2        LAYTER    72  ASPK                   12/75
DP       81K SEE TEXT SEC VI C.2        LAYTER    73  ASPK                   12/75

A0      ALPHA PARAMETER FOR ETA TO 3 PI0
A0      MATRIX ELEMENT **2 = 1 + 2*ALPHA*Z (SEE TEXT SEC VI C.3)             12/75
A0      192   -0.32       0.37          BAGLIN    70  HLBC                   12/75
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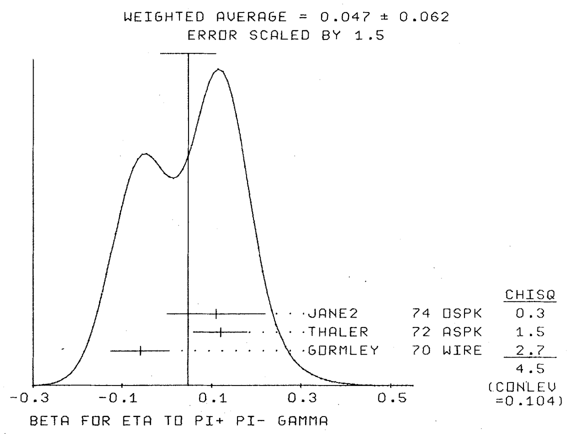
Stable Particles

η, K±

Data Card Listings

For notation, see key at front of Listings.

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REFERENCES FOR ETA


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PEVSNER  61 PRL 7 421            PEVSNER,KRAEMER,NUSSBAUM,RICHARDSON + (JHU)

ALFF     62 PRL 9 322            ALFF,BERLEY,COLLEY,BRUGGER + (COLU+RUTGERS)
BASTIEN  62 PRL 8 114            BASTIEN,BERGE,DAHL,FERRO-LUZZI +      (LRL)
CHRETIEN 62 PRL  9  127          CHRETIEN+   (BRAN+BROWN+HARVARD+MIT+PADOVA)
PICKUP   62 PRL 8 329            E PICKUP,ROBINSON,SALANT        (CNRC+BNL)
SHAFER   62 CERN CONF 307        J SHAFER,FERRO-LUZZI,MURRAY +    (UCB+LRL)

BACCI    63 PRL 11 37            BACCI,PENSO,SALVINI +           (ROMA+FRAS)
BUSCHBEC 63 SIENA CONF 1 166     BUSCHBECK-CZAPP,COOPER + (VIENNA,CERN,AMST)
CRAWFORD 63 PRL 10 546           F S CRAWFORD,LLOYD,FOWLER       (LRL+DUKE)
   ALSO  66 PRL 16 907           F S CRAWFORD,L LLOYD,E FOWLER   (LRL+DUKE)
DELCOURT 63 PL 7 215             DELCOURT,LEFRANCOIS,PEREZ Y JORBA+ (ORSAY)
MULLER   63 SIENA CONF 99        MULLER,PAULI +                  (SACL+RCMA)

FOELSCHE 64 PR 134 B 1138        H W FOELSCHE,H L KRAYBILL             (YALE)
KRAEMER  64 PR 136 B 496         KRAEMER,MADANSKY,FIELDS +   (JHU+NWES+WCOD)
PAULI    64 PL 13 351            E PAULI,A MULLER                    (SACLAY)

FOSTER1  65 PR 138 B 652         FOSTER,PETERS,MEER,LOEFFLER + (WISC+PURDUE)
FOSTER2  65 ATHENS               FOSTER,GOOD,MEER                 (WISCONSIN)
FOSTER3  65 THESIS               M.C.FOSTER                       (WISCONSIN)
PRICE    65 PRL  15  123         L.R.PRICE,F.S.CRAWFORD                 (LRL)
RITTENBE 65 PRL 15 556           RITTENBERG,KALBFLEISCH             (LRL+BNL)

ALFF-STE 66 PR 145 1072          ALFF-STEINBERGER,BERLEY+ (COLUMBIA+RUTGERS)
BALTAY   66 PRL 16 1224          +FRANZINI,KIM,KIRSCH+(COLUMBIA+STONY BROOK)
CLPWY    66 PR 149  1044         COLUMBIA,LRL,PURDUE,WISCONSIN,YALE
CNOPS    66 PL 22 546            CNOPS,FINOCCHIARS,LASSALLE,+(CERN,ETH,SACL)
CRAWFORD 66 PRL  16  333         F.S.CRAWFORD,L.R.PRICE                 (LRL)

DIGIUGNO 66 PRL 16 767           DIGIUGNO,GIORGI,SILVESTRI+ (NAPL,TRST,FRAS)
GROSSMAN 66 PR 146   993         R GROSSMAN,L PRICE,F CRAWFORD          (LRL)
GRUNHAUS 66 THESIS               J.GRUNHAUS                        (COLUMBIA)
JAMES    66 PR 142    896        F E JAMES,H L KRAYBILL            (YALE+BNL)
JONES    66 PL 23   597          JONES,BINNIE,DUANE,HORSEY,MASON,(LCIC,RHEL)
LARRIBE  66 PL 23 600            LARRIBE,LEVEQUE,MULLER,PAULI,+  (SACL+RHEL)
WAHLIG   66 PRL  17  221         WAHLIG,SHIBATA,MANNELLI           (MIT+PISA)

BAGLIN1  67 PL 24B 637           BAGLIN,BEZAGUET,DEGRANGE,+        (EPOL+UCB)
BAGLIN2  67 BAPS 12 567          BAGLIN,BEZAGUET,DEGRANGE,+        (EPOL+UCB)
BALTAY1  67 PRL 19 1495          BALTAY,FRANZINI,KIM,NEWMAN+      (COLU+BRAN)
BALTAY2  67 PRL 19 1498          BALTAY,FRANZINI,KIM,NEWMAN+      (COLU+STON)
BEMPORAD 67 PL 25B 380           BEMPORAD,BRACCINI,FOA,LUBELSMEY+(PISA,BCNN)
   ALSO     PRIVATE COMMUNICATION

BILLING  67 PL 25B 435           BILLING,BULLOCK,ESTEN,GOVAN,+     (LOUC,OXF)
BONAMY   67 HEIDELBERG CONF.     BONAMY,SONDEREGGER                  (SACLAY)
BOWEN    67 PL 24B 206           BOWEN,CNOPS ,FINOCCHIARO,+  (CERN+ETH+SACL)
BUNIATOV 67 PL 25B 560           BUNIATOV,ZAVATTINI,DEINET,+      (CERN+KARL)

CENCE    67 PRL 19 1393          CENCE,PETERSON,STENGER,CHIU+   (HAWAII+LRL)
ESTEN    67 PL 24B 115           +GOVAN,KNIGHT,MILLER,TOVEY+       (LOUC+OXF)
FELDMAN  67 PRL 18 868           FELDMAN,FRATI,GLEESON,HALPERN,+       (PENN)
FLATTE   67 PRL 18 976           S.M.FLATTE                             (LRL)
FLATTE2  67 PR 163 1441          S.M.FLATTE AND C.G.WOHL                (LRL)
LITCHFIE 67 PL 24B 486           LITCHFIELD,RANGAN,SEGAR,SMITH+(RHEL+SACLAY)
PRICE    67 PRL 18 1207          L.R.PRICE,F.S.CRAWFORD                 (LRL)

ARNOLD   68 PL 27B 466           +PATY,BAGLIN,BINGHAM+  (STRB+MADR+EPOL+UCB)
BAZIN    68 PRL 20 895           BAZIN,GOSHAW,ZACHER,+    (PRINCETON,QUEENS)
BULLOCK  68 PL 27B 402           +ESTEN,FLEMING,GOVAN,HENDERSON,OWEN+ (LOUC)
GORMLEY3 68 PRL 21 402           GORMLEY,HYMAN,LEE,NASH,PEOPLES+  (COLU+BNL)
WEHMANN  68 PRL 20 748           WEHMANN,ENGELS,+ (HARV+CASE+SLAC+CORN+MCGI)

BAGLIN   69 PL 29B 445           BAGLIN,BEZAGUET,+       (EPOL,UCB,MADR,STRB)
   ALSO  70 NP B22 66            +BEZAGUET,DEGRANGE,MUSSET +(EPOL,MADR,STRB)
HYAMS    69 PL 29B 128           HYAMS,KOCH,POTTER,VON LINDERN,+ (CERN,MPIM)
JACQUET  69 NC 58 743            JACQUET,NGUYEN-KHAC,HAATUFT+      (EPOL,BERG)
MULLER   69 THESIS               ARMAND MULLER                         (STRB)

BAGLIN   70 NP B22 66            +BEZAGUET,DEGRANGE,MUSSET+ (EPOL+MADR+STRB)
BUTTRAM  70 PRL 25 1358          +KREISLER,MISCHKE                     (PRIN)
CARPENTR 70 PR D1 1303           CARPENTER,BINKLEY,CHAPMAN,COX,DAGAN+ (DUKE)
COX      70 PRL 24 534           COX,FORTNEY,GOLSON                    (DUKE)

DANBURG  70 PR D2 2564           +ABOLINS,DAHL,DAVIES,HOCH,KIRZ,+       (LRL)
DEVONS   70 PR D1 1936           +GRUNHAUS,KOZLOWSKI,NEMETHY +    (COLU,SYRA)
GORMLEY  70 PR D2 501            GORMLEY,HYMAN,LEE,NASH,PEOPLES+  (COLU+BNL)
   ALSO  70 NEVIS 181(THESIS)    MICHAEL GORMLEY                       (COLU)
KANOFSKY 70 NC 68 413            A. KANOFSKY                           (LEHI)
SCHMITT  70 PL 32B 638           +BUNIATOV,ZAVATTINI,DEINET+      (CERN,KARL)

BASILE   71 NC 3A 796            +BOLLINI,DALPIAZ,FRABETTI+ (CERN,BGNA,STRB)
STRUGALS 71 NP B27 429           +CHUVILO,GEMESY,IVANOVSKAYA+          (JINR)
AGUILAR- 72 PR D6 29             AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS    (BNL)
BLOODWOR 72 NP B39 525           BLOODWORTH,JACKSON,PRENTICE,YOON (TORONTO)
LAYTER   72 PRL 29 316           +APPEL,KOTLEWSKI,LEE,STEIN,THALER     (COLU)
THALER   72 PRL 29 313           +APPEL,KOTLEWSKI,LAYTER,LEE,STEIN     (CCLU)

LAYTER   73 PR D7 2565           +APPEL,KOTLEWSKI,LEE,STEIN,THALER     (COLU)
THALER   73 PR D7 2569           +APPEL,KOTLEWSKI,LAYTER,LEE,STEIN     (COLU)
BROWMAN  74 PRL 32 1067          +DEWIRE,GITTELMAN,HANSON,LOH +  (CORN+BING)
DAVIES   74 NC 24A 324           +GUY,ZIA                   (BIRM+RHEL+SHMP)
JANE1    74 PL 48B 260           +JONES,LIPMAN,OWEN,PENNEY+ (RHEL+LOWC+SUSS)
JANE2    74 PL 48B 265           +JONES,LIPMAN,OWEN,PENNEY+ (RHEL+LOWC+SUSS)
KENDALL  74 NC 21A 387           +LANOU,MASSIMO,SHAPIRO +    (BROW+BARI+MIT)

JANE1    75 PL 59B 99            +GRANNIS,JONES,LIPMAN,OWEN +     (RHEL+LOWC)
JANE2    75 PL 59B 103           +GRANNIS,JONES,LIPMAN,OWEN +     (RHEL+LOWC)
   ALSO  76 PL (TO BE PUBL.)     ERRATUM, M.R.JANE, PRIVATE COMMUNICATION.
MARTYNOV 76 SJNP 23 48           +SALTYKOV,TARASOV,UZHINSKII           (JINR)
BUSHNIN  78 PL 79B 147           +DZHELYADIN,GOLOVKIN,GRITSUCK +       (SERP)
   ALSO  78 SJNP 28 775          BUSHNIN,GOLOVKIN,GRITSUK,DZHELYADIN+  (SERP)

       QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

BASTIEN  62 PRL 8 114            BASTIEN,BERGE,DAHL,FERRO-LUZZI,MILLER+(LRL)
CARMONY  62 PRL 8 117            D CARMONY,A ROSENFELD,VAN DE WALLE     (LRL)
ROSENFEL 62 PRL 8 293            A ROSENFELD,D CARMONY,VAN DE WALLE     (LRL)
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K±

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                 10  CHARGED K(494,JP=0-) I=1/2
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                 10  CHARGED K MASS (MEV)

M          493.9       0.2          COHEN     57 RVUE +
M          493.7       0.3          BARKAS    63 EMUL  -
M          493.78      0.17         GREINER   65 EMUL +   VIA TAU DECAY    7/66
M   A     (493.87)    (0.19)        KUNSELMAN 71 CNTR  - KAONIC ATOMS     10/71
M          493.691     0.040        BACKENSTO 73 CNTR  - KAONIC ATOMS      1/73
M  A       493.662     0.19         KUNSELMAN 74 CNTR  - KAONIC ATOMS      3/74
M          493.657     0.020        CHENG     75 CNTR -  KAONIC ATOMS      6/77
M          493.670     0.029        BARKOV    79 EMUL +- E+E- --> K+ K-    7/79*
M  A    KUNSELMAN 74 UPDATES KUNSELMAN 71 WITH IMPROVED KAONIC ATOM CALC.  3/74
M          . . . . . . . . . .
M   AVG    493.668     0.015    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT 493.668    0.017    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M   FIT    493.669     0.015   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*

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                 10  (K+) - (K-) MASS DIFFERENCE (MEV)

DM F  1.5M   -0.032    0.090            FORD      72 ASPK +-               4/72
DM F     FORD 72 USES M(PI+)-M(PI-) = +28+-70 KEV.                         1/73

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                 10  CHARGED K MEAN LIFE (UNITS 10**-8)

T        CHAR. K MEAN LIFE
T   O         (0.95)   (0.36)    (0.25) ILOFF      56 EMUL
T   O   52    (1.60)   (0.3)     (0.3)  EISENBERG  58 EMUL
T              1.21     0.06      0.06  BURROWES   59 CNTR
T   O   33    (1.38)   (0.24)    (0.24) FREDEN     60 EMUL
T   O         (1.25)   (0.22)    (0.17) BARKAS     61 EMUL
T   O   51    (1.27)   (0.36)    (0.23) BHOWMIK    61 EMUL
T      293     1.31     0.08      0.08  NORDIN     61 HBC   -
T             (1.24)   (0.07)           NORDIN     61 RVUE  -
T              1.231    0.011     0.011 BOYARSKI   62 CNTR +
T              1.2443   0.0038          FITCH      65 CNTR +  K AT REST       6/66
T              1.221    0.011           FORD       67 CNTR +-                 8/67
T              1.2272   0.0036          LOBKOWICZ  69 CNTR +  K IN FLIGHT     9/66
T       3M     1.2380   0.0016          OTT        71 CNTR  +  STOPPING  K    2/71
T   O    OLD EXPERIMENTS WITH LARGE ERRORS EXCLUDED FROM AVERAGING            2/71
T            . . . . . . . . . .
T   AVG        1.2370   0.0032   0.0032 AVERAGE (ERROR INCL. SCALE FACTOR OF 2.4)
T   STUDENT    1.2374   0.0016   0.0016 AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
T   FIT        1.2371   0.0026 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)
                        (SEE IDEOGRAM BELOW )
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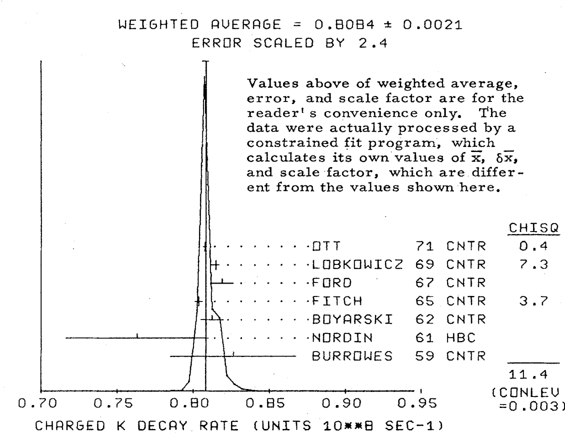


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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

$K^{\pm}$

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           10  ((K+) - (K-))/AVG., MEAN LIFE DIFFERENCE (PERCENT)

DT   N    THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W.I.

DT             0.47      0.30           FORD       67 CNTR                      8/67
DT             0.090     0.078          LOBKOWICZ 69 CNTR                      12/70
DT             . . . . . . . . . .
DT   AVG       0.114     0.093   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
DT   STUDENT   0.112     0.083   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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                 10  CHARGED K PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     CHAR. K INTO MU NEU                 K MU2          105+   0
P2     CHAR. K INTO PI PIO                 K PI2          139+ 134
P3     CHAR. K INTO PI PI+ PI-             TAU            139+ 139+ 139
P4     CHAR. K INTO PI 2PIO                TAU PRIME      139+ 134+ 134
P5     CHAR. K INTC MU PIO NEU             K MU3          105+ 134+   0
P6     CHAR. K INTO E PIO NEU              K E3            .5+ 134+   0
P7     K+ INTO PI+ PI- E+ NEU              K E+ 4         139+ 139+  .5+   0
P8     K+ INTO PI+ PI+ E- NEU              K E- 4         139+ 139+  .5+   0
P9     K+ INTO PI+ PI- MU+ NEU             K+MU+ 4        139+ 139+ 105+   0
P10    K+ INTO PI+ PI+ MU- NEU             K+MU- 4        139+ 139+ 105+   0
P11    CHAR. K INTO E NEU                  K E2            .5+   0
P12    CHAR. K INTC MU NEU GAMMA           K MU RAD       105+   0+    0
P13    CHAR. K INTC PI PIO GAMMA           K PI RAD       139+ 134+    0
P14    CHAR. K INTO PI PI+ PI- GAMMA       TAU RAD        139+ 139+ 139+   0
P15    CHAR. K INTO PI E+ E-               PI E E         139+  .5+  .5
P16    CHAR. K INTO PI MU+ MU-             PI MU MU       139+ 105+ 105
P17    CHAR. K INTO PI GAMMA GAMMA         PI GAM GAM     139+   0+    0
P18    CHAR. K INTO PIO E NEU GAMMA        PI E NEU GAM   134+  .5+   0+   0
P19    K+- INTO PI-+ E+- E+-               PI-+E+-E+-     139+  .5+  .5
P20    CHAR. K INTO PI NEU NEU             PI NEU NEU     139+   0+    0
P21    CHAR. K INTO E NEU GAMMA            K E2 RAD        .5+   0+    0
P22    CHAR. K INTO PI GAMMA               K PI GAM       139+   0
P23    CHAR. K INTO PI 3GAMMA              PI 3GAM        139+   0+   0+   0
P24    CHAR. K INTO PIO PIO E NEU          K E4 2PIO      134+ 134+  .5+   0
P25    K+ INTO PI- E+ MU+                  PI-E+MU+       139+  .5+ 105
P26    K+ INTO PI+ E+ MU-                  PI+E+MU-       139+  .5+ 105
P27    CHAR. K INTO MU NEU NEU NEUBAR      MU 3NEU        105+   0+   0+   0
P28    CHAR. K INTO PIO MU NEU GAMMA       PI MU NEU GAM  134+ 105+   0+   0
P29    K+ INTO PI+ MU+ E-                  PI+MU+E-       139+ 105+  .5
P30    CHAR. K INTC MU NEU E+ E-           MU NEU E+E-    105+   0+  .5+  .5
P31    K+- INTO MU-+ NEU E+- E+-           MU-+ NEU 2E+-  105+   0+  .5+  .5
P32    CHAR. K INTO NEU E E E              NEU 3E           0+  .5+  .5+  .5
P33    CHAR. K INTO E NEU NEU NEUBAR       E 3NEU          .5+   0+   0+   0
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                   CHARGED K CONSTRAINED FIT
              OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING
              RATIOS USES 59 DATA POINTS TO DETERMINE SIX                3/78
              QUANTITIES.  OVERALL FIT HAS CHISQ=78.0.  MAIN             3/78
              CONTRIBUTION (13.2) COMES FROM R19 OF HAIDT                3/78
              71 (WE SEE NO REASON TO REJECT THIS EXPERIMENT
              AT THIS TIME)
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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.6350+-.0016					
P 2	-.7380	.2116+-.0015				
P 3	-.1919	-.0353	.0559+-.0003			
P 4	-.1818	.0349	.2039	.0173+-.0005		
P 5	-.2726	-.2321	-.1178	-.3230	.0320+-.0009	
P 6	-.3389	-.1385	.1500	.0257	.2125	.0482+-.0005

FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e., $G_i \equiv \Gamma_i = \Gamma_{total} P_i$, in appropriate units. In analogy to the matrix above, the diagonal elements are $G_i \pm \delta G_i$, where $\delta G_i = \sqrt{\langle \delta G_i \delta G_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta G_i \delta G_j \rangle / (\delta G_i \cdot \delta G_j)$. Note that, because of the error in Γ_{total}, the errors and correlations here are not directly derivable from those above.

	G 1	G 2	G 3	G 4	G 5	G 6
G 1	.5133+-.0017					
G 2	-.3275	.1710+-.0013				
G 3	-.0991	-.0024	.0452+-.0002			
G 4	-.1076	.0488	.2062	.0140+-.0004		
G 5	-.1623	-.1977	-.1229	-.3193	.0258+-.0007	
G 6	-.1552	-.0804	.1532	.0309	.2197	.0390+-.0004

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                10  CHARGED K DECAY RATES

W1     CHAR. K INTC MU NEU (UNITS 10**6 SEC-1)          (G1)
W1            51.2        0.8          FORD        67 CNTR +-                  8/67
W1          . . . . . . . . . .
W1   FIT      51.33       0.17   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

W2     CHAR. K INTO PI PI+ PI- (UNITS 10**6 SEC-1)      (G3)
W2   F       (4.496)    (0.030)        FORD        67 CNTR +- SEE NOTE F        8/67
W2   F 3.2M  (4.529)    (0.032)        FORD        70 ASPK    SEE NOTE F       11/70
W2            4.511      0.024         FORD        70 ASPK    SEE NOTE F       11/70
W2   F    THE LAST IS THE COMBINED RESULT OF FORD 67 AND FORD 70
W2          . . . . . . . . . .
W2   FIT      4.517      0.023   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

W3     CHAR. K INTO (TAU) - (TAU PRIME) (UNITS 10**6 SEC-1)
W3                                                         (G3-G4)
W3       USED FOR DELTA I = 1/2 TEST.
W3          . . . . . . . . . .
W3   FIT      3.117      0.039   FROM FIT

W4     CHAR. K INTO (MU PIO NEU) + (E PIO NEU) (UNITS 10**6 SEC-1)
W4                                                         (G5+G6)
W4       USED FOR DELTA I = 1/2 TEST.
W4          . . . . . . . . . .
W4   FIT      6.484      0.089   FROM FIT
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           10  ((K+) - (K-))/AVG., DECAY RATE DIFFERENCE (PERCENT)

D1     DIFFERENCE IN K MU2 RATES      ((G1+)-(G1-))/G1        (PERCENT)
D1            -0.54      0.41          FORD       67 CNTR                       8/67

D2     DIFFERENCE IN TAU RATES        ((G3+)-(G3-))/G3        (PERCENT)
D2            -0.50      0.90          FLETCHER   67 OSPK                       8/67
D2   F       (-0.04)    (0.21)         FORD       67 CNTR    SEE NOTE F         8/67
D2   F 3.2M   (0.10)    (0.14)         FORD       70 ASPK    SEE NOTE F        11/70
D2 F           0.08      0.12          FORD       70 ASPK    SEE NOTE F        11/70
D2   S       (-0.02)    (0.16)         SMITH      73 ASPK +-                   11/73
D2   F    SECOND FORD 70 VALUE IS FIRST FORD 70 COMBINED WITH FORD 67.
D2   S    SMITH 73 VALUE OF D2 IS DERIVED FROM SMITH 73 VALUE OF D3.           11/73
D2          . . . . . . . . . .
D2   AVG       0.07      0.12    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D2   STUDENT   0.07      0.13    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

D3     DIFFERENCE IN TAU PRIME RATES ((G4+)-(G4-))/AVERAGE    (PERCENT)
D3    1802    -1.1       1.8           HERZO      69 OSPK                       5/70
D3             0.08      0.58          SMITH      73 ASPK +-                   11/73
D3          . . . . . . . . . .
D3   AVG      -0.03      0.55    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D3   STUDENT  -0.03      0.60    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

D4     DIFFERENCE IN K PI2 RATES      ((G2+)-(G2-))/AVERAGE   (PERCENT)
D4             0.8       1.2           HERZO      69 OSPK                       5/70

D5     DIFFERENCE IN K PI RAD RATES  ((G13+)-(G13-))/AVERAGE (PERCENT)
D5      24     0.0      24.0           EDWARDS    72 OSPK    PI KE 58-90 MEV   8/72
D5    4000     1.0       4.0           ABRAMS     73 ASPK +- PI KE 51-100 MEV  3/74
D5    2461     0.8       5.8           SMITH      76 WIRE +- PI+-KE 55-90 MEV 11/76
D5          . . . . . . . . . .
D5   AVG       0.9       3.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D5   STUDENT   0.9       3.5     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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                10  CHARGED K BRANCHING RATIOS

R    O       OLD DATA EXCLUDED

R1     CHAR. K INTO (MU NEU)/TOTAL (UNITS 10**-2)          (P1)
R1   O        (58.5)     (3.0)         BIRGE      56 EMUL +
R1   O        (56.9)     (2.6)         ALEXANDER 57 EMUL +
R1   O    OLD EXPERIMENTS NOT INCLUDED IN AVERAGING                            1/71
R1     62K    63.24      0.44          CHIANG     72 OSPK + 1.84 GEV/C K+      9/72
R1          . . . . . . . . . .
R1   FIT      63.50      0.16    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2     CHAR. K INTO (PI PIO)/TOTAL (UNITS 10**-2)          (P2)
R2   O        (27.7)     (2.7)         BIRGE      56 EMUL +
R2   O        (23.2)     (2.2)         ALEXANDER 57 EMUL +
R2   O    EARLIER EXPERIMENTS NOT AVERAGED
R2            (21.0)     (0.6)         CALLAHAN   65 HLBC    SEE R17
R2            (21.6)     (0.6)         TRILLING   65 RVUE                      6/66
R2     16K    21.18      0.28          CHIANG     72 OSPK + 1.84 GEV/C K+      9/72
R2          . . . . . . . . . .
R2   FIT      21.16      0.15    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3     CHAR. K INTO (PI PI+ PI-)/TOTAL (UNITS 10**-2)    (P3)
R3   O         (5.6)     (0.4)         BIRGE      56 EMUL +
R3   O         (6.8)     (0.4)         ALEXANDER 57 EMUL +
R3   O         (5.2)     (0.3)         TAYLOR     59 EMUL +
R3   O    EARLIER EXPERIMENTS NOT AVERAGED
R3              5.7      0.3           ROE        61 HLBC +                    9/66
R3    2332      5.54     0.12          CALLAHAN   64 HLBC +
R3     540      5.1      0.2           SHAKLEE    64 HLBC +                    9/66
R3              5.71     0.15          DE MARCO   65 HBC                       6/66
R3      44      6.0      0.4           YOUNG      65 EMUL +                    6/66
R3 P   693      5.34     0.21          PANDOULAS 70 EMUL +                    10/70
R3  C 2330     (5.56)   (0.20)         CHIANG     72 OSPK + 1.84 GEV/C K+      9/72
R3  C   THIS VALUE IS NOT INDEPENDENT OF CHIANG 72 R1,R2,R4,R5, AND R6         9/72
R3 P    INCLUDES EVENTS OF TAYLOR 59.
R3          . . . . . . . . . .
R3   AVG       5.521     0.098   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R3   STUDENT   5.533     0.089   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3   FIT       5.588     0.030  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                                (SEE IDEOGRAM BELOW )
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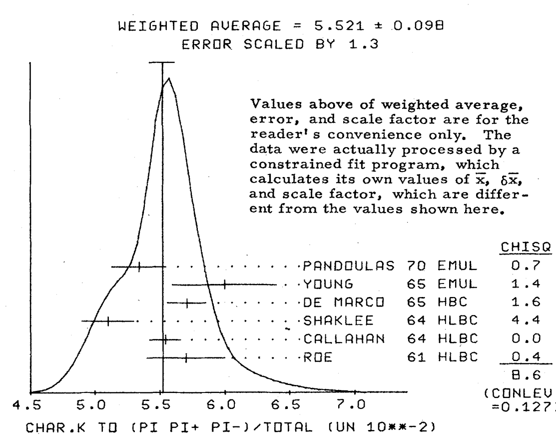

Stable Particles

$K^{\pm}$

Data Card Listings

For notation, see key at front of Listings.

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R4      CHAR. K INTO (PI 2PIO)/TOTAL (UNITS 10**-2)        (P4)
R4  O          (2.1)      (0.5)            BIRGE      56 EMUL +
R4  O          (2.2)      (0.4)            ALEXANDER  57 EMUL +
R4  O          (1.5)      (0.2)            TAYLOR     59 EMUL +
R4  O   EARLIER EXPERIMENTS NOT AVERAGED
R4              1.7        0.2             ROE        61 HLBC +                   11/67
R4      108     1.8        0.2             SHAKLEE    64 HLBC +                   11/67
R4 P    198     1.53       0.11            PANDOULAS  70 EMUL +                   10/70
R4     1307     1.84       0.06            CHIANG     72 OSPK +  1.84 GEV/C K+     9/72
R4 P    INCLUDES EVENTS OF TAYLOR 59.
R4             . . . . . . . . .
R4  AVG         1.767      0.071   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R4  STUDENT     1.778      0.063   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R4  FIT         1.732      0.045  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
                           (SEE IDEOGRAM BELOW )
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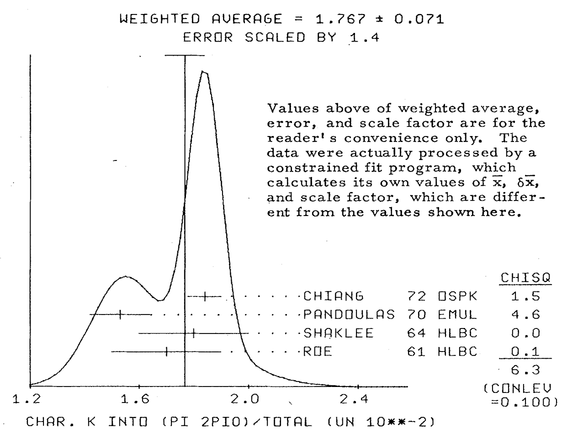


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R5      CHAR. K INTO (MU PIO NEU)/TOTAL (UNITS 10**-2)    (P5)
R5  O          (2.8)      (1.0)            BIRGE      56 EMUL +
R5  O          (5.9)      (1.3)            ALEXANDER  57 EMUL +
R5  O          (2.8)      (0.4)            TAYLOR     59 EMUL +
R5  O   EARLIER EXPERIMENTS NOT AVERAGED
R5    2345     3.33       0.16             CHIANG     72 OSPK +  1.84 GEV/C K+     9/72
R5             . . . . . . . . .
R5  FIT        3.197      0.086   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

R6      CHAR. K INTO (E PIO NEU)/TOTAL (UNITS 10**-2)     (P6)
R6  O          (3.2)      (1.3)            BIRGE      56 EMUL +
R6  O          (5.1)      (1.3)            ALEXANDER  57 EMUL +
R6  O   EARLIER EXPERIMENTS NOT AVERAGED
R6             5.0        0.5              ROE        61 HLBC +                   11/67
R6     429     4.7        0.3              SHAKLEE    64 HLBC +                   11/67
R6    3516     4.86       0.10             CHIANG     72 OSPK +  1.84 GEV/C K+     9/72
R6             . . . . . . . . .
R6  AVG        4.849      0.093    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6  STUDENT    4.85       0.10     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R6  FIT        4.824      0.052   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R7      CHAR. K INTO (PI2 + MU3)/TOTAL (UNITS 10**-2)     (P2+P5)                  11/67
R7       WE COMBINE THESE TWO MODES FOR EXPTS MEASURING THEM IN XENON BC
R7       BECAUSE OF DIFFICULTIES OF SEPARATING THEM THERE
R7             23.4       1.1              ROE        61 HLBC +                   11/67
R7     886     25.4       0.9              SHAKLEE    64 HLBC +                   11/67
R7             . . . . . . . . .
R7  AVG        24.60      0.98     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R7  STUDENT    24.61      0.83     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R7  FIT        24.36      0.15    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R8      K+ INTO (PI+ PI+ E- NEU)/TOTAL (UNITS 10**-7)     (P8)
R8             20.     OR LESS  CL=.95    BIRGE       65 FBC  +                    8/66
R8        0    6.9     OR LESS  CL=.95    ELY         69 HLBC +                   10/69
R8        0    9.0     OR LESS  CL=.95    SCHWEINBE   71 HLBC +                    9/71

R9      K+ INTO (PI+ PI- MU+ NEU)/TOTAL (UNITS 10**-5)    (P9)
R9        1     0.77      0.54      0.50  CLINE       65 FBC  +                    8/66

R10     K+ INTO (PI+ PI+ MU- NEU)/TOTAL (UNITS 10**-6)    (P10)
R10       0     3.0    OR LESS  CL=.95    BIRGE       65 FBC  +                    8/66

R11     CHAR. K INTO (E NEU)/TOTAL (UNITS 10**-5)         (P11)
R11          160.0     OR LESS  CL=.95    BORREANI    64 HBC  +                   11/67
R11       4     2.1       1.8       1.3   BOWEN       67 OSPK +                    8/67
R11      BOWEN RESULT SHOULD BE CORRECTED TO 1.9(+1.7,-1.2) BECAUSE OF
R11      K+ TO E+ NEU GAMMA DECAYS BEFORE COMPARING WITH BOTTERILL 67 R28

R12     CHAR. K INTO (PI GAMMA GAMMA)/TOTAL (UNITS 10**-4)
R12                                                        (P17)
R12      ALL VALUES GIVEN HERE ASSUME A PHASE SPACE PION ENERGY SPECTRUM         2/72
R12           -0.1       0.6               CHEN        68 OSPK +  T(PI) 60-90 MEV   9/73
R12       0    0.5     OR LESS  CL=.90    KLEMS       71 OSPK +  T(PI)GT 117 MEV   8/71
R12       0    0.35    OR LESS  CL=.90    LJUNG       73 HLBC +  6-102,114-127MEV  9/73
R12       0   -0.42      0.52              ABRAMS      77 SPEC +  T(PI)LT 92 MEV   12/77

R13     CHAR. K INTO (PI PIO GAMMA)/TOTAL (UNITS 10**-4) (P13)
R13 O   18    (2.2)     (0.7)              CLINE       64 FBC  +  PI+ KE 55-80 MEV  8/66
R13      0     1.9     OR LESS  CL=.90    EMMERSON    69 OSPK    PI+ KE 55-80 MEV 10/69
R13  M   0     1.0     OR LESS             MALTSEV     70 HLBC +  PI+ KE LT 55 MEV 12/75
R13  A2100     2.71      0.19              ABRAMS      72 ASPK +- PI+ KE 55-90 MEV  1/73
R13 O   24    (2.4)     (0.8)              EDWARDS     72 OSPK    PI+ KE 58-90 MEV  8/72
R13 L         (1.5)     (1.1)     (0.6)    LJUNG       73 HLBC +  PI+ KE 55-80 MEV  9/73
R13 L         (2.6)     (1.5)     (1.1)    LJUNG       73 HLBC +  PI+ KE 55-90 MEV  9/73
R13 OL  17    (6.8)     (3.7)     (2.1)    LJUNG       73 HLBC +  PI+ KE 55-102MEV  9/73
R13   2461     2.87      0.32              SMITH       76 WIRE +- PI+-KE 55-90 MEV 11/76
R13 O   ONLY HIGH STATISTICS EXPERIMENTS ARE AVERAGED.                          3/78
R13  M  MALTSEV 70 SELECTS LOW PI+ ENERGY TO ENHANCE DIRECT EMISSION CONTR.  1/76
R13  L  THE LJUNG 73 VALUES ARE NOT INDEPENDENT.                               9/73
R13  A  ABRAMS 72 OBSERVES DIRECT EMISSION BR. RATIO OF (1.56+-0.35)*10**-5  1/73
R13  A  +-0.5*10**-5 ADDNL. SYST. ERROR  AND INNER BREMSSTRAHLUNG BR. RATIO  1/73
R13  A  OF (2.55+-0.18)*10**-4.  WE QUOTE THE SUM OF THESE BR. RATIOS.       1/73
R13            . . . . . . . . .
R13 AVG        2.75      0.16      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R13 STUDENT    2.75      0.18      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R14     CHAR. K INTO (PI PI+ PI- GAMMA)/TOTAL (UNITS 10**-4)
R14                                                       (P14)
R14            1.0       0.4               STAMER     65 EMUL +  EGAM GT 11MEV     8/66

R15     CHAR. K INTO (PI E+ E-)/TOTAL (UNITS 10**-6)      (P15)
R15       1    2.45    OR LESS  CL=.90    CAMERINI   64 FBC  +                    8/66
R15            4.4     OR LESS  CL=.90    BISI       67 DBC  +                   11/67
R15 C         (0.4)    OR LESS             CLINE1     67 FBC  +                  .11/67
R15 C          0.88    OR LESS  CL=.90    CLINE2     67 FBC  +                  . 2/74
R15           32.0     OR LESS  CL=.90    BEIER      72 OSPK +-                   9/72
R15            1.7     OR LESS  CL=.90    CENCE      74 ASPK +  THREE TRACK EVTS 10/74
R15            0.27    OR LESS  CL=.90    CENCE      74 ASPK +  TWO TRACK EVENTS 10/74
R15 C  CLINE2 REPLACES CLINE1.  CLINE1 IS NOT FOR CL=.90 .                       2/74

R16     CHAR. K INTO (PI MU+ MU-)/TOTAL (UNITS 10**-6)    (P16)
R16            3.0     OR LESS  CL=.90    CAMERINI   65 FBC  +                    8/66
R16            2.4     OR LESS  CL=.90    BISI       67 DBC  +                   11/67

R17     CHAR. K INTO (PI PIO)/TAU                          (P2)/(P3)
R17     134    3.24      0.34              YOUNG      65 EMUL +                  . 8/66
R17    1045    3.96      0.15              CALLAHAN   66 FBC  +                    9/66
R17            . . . . . . . . .
R17 AVG        3.84      0.27      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
R17 STUDENT    3.86      0.16      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R17 FIT        3.787     0.034   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R18     CHAR. K INTO (PI 2PIO)/TAU                         (P4)/(P3)
R18    2027    0.303     0.009             BISI       65 H+HL +                  . 8/66
R18      17    0.393     0.099             YOUNG      65 EMUL +                    8/66
R18            . . . . . . . . .
R18 AVG        0.3037    0.0090    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R18 STUDENT    0.3037    0.0097    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R18 FIT        0.3100    0.0079  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R19     CHAR. K INTO (MU PIO NEU)/TAU                      (P5)/(P3)
R19    2845    0.632     0.035             BISI 1     65 H+HL +                  . 8/66
R19      38    0.90      0.16              YOUNG      65 EMUL +                    8/66
R19 H 1505    (0.510)   (0.017)            EICHTEN    68 HLBC +                   11/68
R19   H1505    0.503     0.019             HAIDT      71 HLBC +                   12/70
R19  H  HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R19            . . . . . . . . .
R19 AVG        0.536     0.054     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.2)
R19 STUDENT    0.527     0.025     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R19 FIT        0.572     0.016   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)
                         (SEE IDEOGRAM BELOW )
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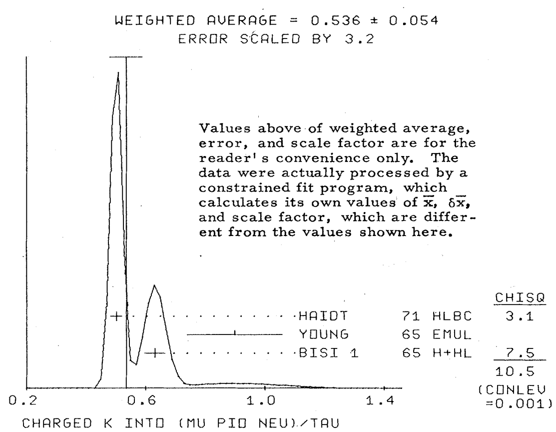


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R20     CHAR. K INTO (E PIO NEU)/TAU                       (P6)/(P3)
R20     230    0.90      0.06              BORREANI   64 HBC  +                  . 8/66
R20      37    0.90      0.16              YOUNG      65 EMUL +                  . 8/66
R20     854    0.94      0.09              BELLOTT2   67 HLBC                     11/67
R20 H 4385    (0.846)   (0.021)            EICHTEN    68 HLBC +                   11/68
R20   H4385    0.850     0.019             HAIDT      71 HLBC +                   12/70
R20    2827    0.856     0.040             BRAUN      75 HLBC +                   12/75
R20  H  HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R20            . . . . . . . . .
R20 AVG        0.858     0.016     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R20 STUDENT    0.858     0.018     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R20 FIT        0.8633    0.0098  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R21     K+ INTO (PI+ PI- E+ NEU)/TAU (UNITS 10**-4)       (P7)/(P3)
R21      69    6.7       1.5               BIRGE      65 FBC  +                    8/66
R21     269    5.83      0.63              ELY        69 HLBC +                   11/68
R21     500    7.36      0.68              BOURQUIN   71 ASPK                     12/71
R21     106    7.0       0.9               SCHWEINBE  71 HLBC +                    9/71
R21     30K    7.21      0.32              ROSSELET   77 SPEC +                   11/77
R21            . . . . . . . . .
R21 AVG        6.98      0.26      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R21 STUDENT    7.02      0.29      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R22     K+ INTO (PI+ PI- MU+ NEU)/TAU (UNITS 10**-4)      (P9)/(P3)
R22       1   (2.5)   APPROX               GREINER    64 EMUL +                    8/66
R22       7    2.57      1.55              BISI       67 DBC  +                   11/67

R23     CHAR. K INTO (E PIO NEU)/(MU2+PI2) (UNITS 10**-2)(P6)/(P1+P2)
R23    1679    5.89      0.21              CESTER     66 OSPK +                    8/67
R23    5110    6.16      0.22              ESCHSTRUT  68 OSPK +                    3/68
R23  W         5.92      0.65              WEISSENBE  76 SPEC +                    1/78
R23  W  VALUE CALCULATED FROM WEISSENBERG 76 KE3, KMU2, KPI2 VALUES             1/78
R23  W  TO ELIMINATE DEPENDENCE ON OUR 1974 TAU AND TAU-PRIME FRACTIONS.        1/78
R23            . . . . . . . . .
R23 AVG        6.01      0.15      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R23 STUDENT    6.01      0.17      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R23 FIT        5.698     0.067   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

$K^{\pm}$

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R24    CHAR. K INTO (PI PIO)/(MU NEU)                         (P2)/(P1)
R24  A4517    0.3277    0.0065          AUERBACH  67 OSPK +                    1/74
R24   1600    0.305     0.018           ZELLER    69 ASPK +                   10/69
R24 W  25K   (0.328)   (0.005)          WEISSENBE 74 STRC +                    7/74
R24  W        0.3355    0.0057          WEISSENBE 76 SPEC +                    1/78
R24  A  AUERBACH 67 CHANGED FROM .3253+-.0065.  SEE COMMENT WITH RATIC R26.   1/74
R24  W  WEISSENBERG 76 REVISES WEISSENBERG 74.                                 1/78
R24         . . . . . . . . . .
R24 AVG       0.3307    0.0051  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R24 STUDENT   0.3307    0.0048  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R24 FIT       0.3332    0.0030 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R25    CHAR. K INTO (E PIO NEU)/(MU NEU)                      (P6)/(P1)
R25  A 295    0.0791    0.0054          AUERBACH  67 OSPK +                    1/74
R25    960     .0775     .0033          BOTTERI1  68 ASPK +                    5/68
R25    561    0.069     0.006           GARLAND   68 OSPK +                    4/68
R25    350    0.069     0.006           ZELLER    69 ASPK +                   10/69
R25  A  AUERBACH 67 CHANGED FROM .0797+-.0054.  SEE COMMENT WITH RATIO R26.   1/74
R25  A  THE VALUE .0785+-.0025 GIVEN IN AUERBACH 67 IS AN AVERAGE OF          3/74
R25  A  AUERBACH 67 R25 AND CESTER 66 R23.                                    3/74
R25         . . . . . . . . . .
R25 AVG       0.0752    0.0024  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R25 STUDENT   0.0753    0.0027  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R25 FIT      0.07597   0.00091 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R26    CHAR. K INTO (MU PIO NEU)/(MU NEU)                     (P5)/(P1)
R26  A 307    0.0486    0.0040          AUERBACH  67 OSPK +                    1/74
R26  G 424    0.0480    0.0037          GARLAND   68 OSPK +                    1/74
R26    240    0.054     0.009           ZELLER    69 ASPK +                   10/69
R26  A  AUERBACH 67 CHANGED FROM .0602+-.0046 BY ERRATUM WHICH BRINGS THE     1/76
R26  A  MU-SPECTRUM CALCULATION INTO AGREEMENT WITH GAILLARD 70 APPENDIX B.   1/74
R26  G  GARLAND 68 CHANGED FROM .055+-.004 IN AGREEMENT WITH MU-SPECTRUM      1/74
R26  G  CALCULATION OF GAILLARD 70 APPENDIX B.  L.G.PONDROM, PRIV.COMM.(73)   1/74
R26         . . . . . . . . . .
R26 AVG       0.0488    0.0026  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R26 STUDENT   0.0487    0.0028  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R26 FIT       0.0503    0.0014 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

R27    CHAR. K INTO (MU NEU)/TAU                              (P1)/(P3)
R27 R  427  (10.38)    (0.82)           YOUNG     65 EMUL +                    9/66
R27 R   DELETED FROM OVERALL FIT BECAUSE YOUNG 65 CONSTRAINS HIS RESULTS.
R27 R   TO ADD UP TO 1.  ONLY YOUNG MEASURED MU2 DIRECTLY.
R27         . . . . . . . . . .
R27 FIT      11.364     0.072   FROM FIT

R28    CHAR. K INTO (E NEU)/(MU NEU) (UNITS 10**-5)      (P11)/(P1)
R28     10    1.9       0.7       0.5   BOTTERILL 67 ASPK +                   11/67
R28      8    1.8       0.8       0.6   MACEK     69 ASPK +                    4/69
R28    112    2.42      0.42            CLARK     72 OSPK +                    1/73
R28    534    2.37      0.17            HEARD2    75 SPEC +                   11/75
R28    404    2.51      0.15            HEINTZE   76 SPEC +                    2/76
R28         . . . . . . . . . .
R28 AVG       2.42      0.11    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R28 STUDENT   2.42      0.12    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R29    CHAR. K INTO (MU PIO NEU)/(E PIO NEU)                  (P5)/(P6)
R29  C1509    0.703     0.056           CALLAHA1  66 HLBC                      6/68
R29   5601    0.667     0.017           BOTTERI2  68 ASPK +                    6/68
R29 H 1398   (0.604)   (0.022)          EICHTEN   68 HLBC                     10/68
R29 H        (0.596)   (0.025)          HAIDT     71 HLBC +                   12/70
R29  D3480    0.698     0.025           CHIANG    72 OSPK +  1.84 GEV/C K+     9/72
R29  L 554    0.705     0.063           LUCAS2    73 HBC  -  DALITZ PRS ONLY  11/73
R29 B 1585   (0.608)   (0.014)          BRAUN     75 HLBC +                    1/76
R29           0.67      0.12            WEISSENBE 76 SPEC +                    1/78
R29 E        (0.670)   (0.014)          HEINTZE   77 SPEC +                   12/77
R29                 COMMENTS
R29  C  FROM CALLAHAN1 66 WE USE ONLY THE MU3/E3 RATIO AND DO NOT
R29  C  INCLUDE IN THE FIT THE RATIOS MU3/TAU AND E3/TAU, SINCE THEY SHOW
R29  C  LARGE DISAGREEMENTS WITH THE REST OF THE DATA.
R29 H   HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R29 H   CNLY INDIVIDUAL RATIOS INCLUDED IN FIT (SEE R19 AND R20).             11/68
R29  D  CHIANG 72 R29 IS STATISTICALLY INDEPENDENT OF CHIANG 72 R5 AND R6.     9/72
R29  L  LUCAS 73 GIVES N(MU3)=554+-7.6PCT, N(E3)=786+-3.1PCT.  WE DIVIDE.     11/73
R29 B   BRAUN 75 VALUE IS FROM FORM FACTOR FIT.  ASSUMES MU-E UNIVERSALITY.    1/76
R29 E   HEINTZE 77 VALUE FROM FIT TO LAMBDAO. ASSUMES MU-E UNIVERSALITY.      12/77
R29         . . . . . . . . . .
R29 AVG       0.679     0.013   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R29 STUDENT   0.679     0.015   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R29 FIT       0.663     0.018  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

R30    CHAR. K INTO (PIO E NEU GAMMA)/(PIO E NEU) (UNITS 10**-2)
R30                                                      (P18)/(P6)
R30           1.2       0.8             BELLOTT1  67 HLBC +  EGAM GT 30MEV    11/67
R30  R  13    0.76      0.28            ROMANO    71 HLBC    EGAM GT 10MEV    10/71
R30 R        (0.53)    (0.22)           ROMANO    71 HLBC +  EGAM GT 30 MEV    9/73
R30  L  16    0.48      0.20            LJUNG     73 HLBC +  EGAM GT 30 MEV    9/73
R30 L        (0.22)    (0.15)    (0.10) LJUNG     73 HLBC +  EGAM GT 30 MEV    9/73
R30 L   FIRST LJUNG VALUE IS FOR COS(ELECT-GAMMA)L.T. 0.9, SECOND VALUE IS     9/73
R30 L   FOR COS(ELECT-GAMMA) BETW 0.6 AND 0.9 FOR COMPARISON WITH ROMANO.      9/73
R30 R   BOTH ROMANO VALUES ARE FOR COS(ELECT-GAMMA) BETW 0.6 AND 0.9.          9/73
R30 R   SECOND VALUE IS FOR COMPARISON WITH SECOND LJUNG VALUE.                9/73
R30 R   WE USE LOWEST EGAM CUT FOR TABLE VALUE. SEE ROMANO FOR EGAM DEPEND.    9/73
R30         . . . . . . . . . .
R30 AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R31    K- INTO (PI+ E- E-)/TOTAL (UNITS 10**-5)          (P19)
R31     TEST OF LEPTCN NUMBER CONSERVATION.
R31           1.5    OR LESS            CHANG     68 HBC   -                   3/68

R32    CHAR. K INTO (PI NEU NEU)/TOTAL (UNITS 10**-6)    (P20)
R32 C        (1.4)   OR LESS  CL=.90    KLEMS     71 OSPK +  T(PI) 117-127MEV  3/74
R32 C        (0.94)  OR LESS  CL=.90    CABLE     73 CNTR +  T(PI) 60-105 MEV  2/74
R32  C        0.56   OR LESS  CL=.90    CABLE     73 CNTR +  T(PI) 60-127 MEV  2/74
R32  L   0   57.0    OR LESS  CL=.90    LJUNG     73 HLBC +                    9/73
R32  C  KLEMS 71 AND CABLE 73 ASSUME PI SPECTRUM SAME AS KE3 DECAY.            3/74
R32  C  SECOND CABLE LIMIT COMBINES CABLE AND KLEMS DATA FOR VECTOR INT.       2/74
R32  L  LJUNG 73 ASSUMES VECTOR INTERACTION.                                   9/73

R33    CHAR. K INTO (E NEU GAMMA)/TOTAL  (UNITS 10**-5) (P21)
R33  M        7.1    OR LESS            MACEK     70 OSPK +  P(E) 234 TO 247  12/70
R33  M  ABOVE IS MEASUREMENT OF STRUCTURE-DEPENDENT DECAY ONLY.

R34    CHAR. K INTO (PI GAMMA)/TOTAL (UNITS 10**-6)      (P22)
R34           4.0    OR LESS  CL=.90    KLEMS     71 OSPK +                    8/71

R35    CHAR. K INTO (TAU)/(TAU PRIME)                    (P3/P4)
R35     USED FOR DELTA I=1/2 TEST.
R35         . . . . . . . . . .
R35 FIT       3.226     0.082   FROM FIT

R36    CHAR. K INTO (PI 3GAMMA)/TOTAL (UNITS 10**-4)     (P23)
R36           3.0    OR LESS  CL=.90    KLEMS     71 OSPK +  T(PI) GT 117MEV   8/71

R37    K+ INTO (PI+ PI+ E- NEU)/(PI+ PI- E+ NEU) (UNITS 10**-4)  (P8)/(P7)
R37     0  130.      OR LESS  CL=.95    BOURQUIN  71 ASPK                      8/76
R37  B   3    3.6    OR LESS  CL=.95    BLOCH     76 SPEC                      8/76
R37  B  CORRESPONDS TO 3E10-4 AT CL=.90.                                       2/80*
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R38    CHAR. K INTO (PIO PIO E NEU)/KE3 (UNITS 10**-4)  (P24)/(P6)
R38     0   37.0   OR LESS  CL=.90    ROMANO     71 HLBC +                   12/71
R38     2    3.8      5.0       1.2   LJUNG      73 HLBC +                    9/73

R39    K+ INTO (PI- E+ MU+)/TOTAL (UNITS 10**-8)          (P25)
R39    K- INTO (PI+ E- MU-)/TOTAL IS ALSO INCLUDED HERE
R39          2.8   OR LESS  CL=.90    BEIER      72 OSPK +-                   9/72

R40    K+ INTO (PI+ E+ MU-)/TOTAL (UNITS 10**-8)          (P26)
R40    K- INTO (PI- E- MU+)/TOTAL IS ALSO INCLUDED HERE
R40          1.4   OR LESS  CL=.90    BEIER      72 OSPK +-                   9/72

R41    CHAR. K INTO (MU 3NEU)/TOTAL (UNITS 10**-6)        (P27)
R41  P   0   6.0   OR LESS  CL=.90    PANG       73 CNTR +                   11/73
R41  P  PANG 73 ASSUMES MU SPECTRUM FROM NEU-NEU INTERACTION OF BARDIN 70.    3/74

R42    CHAR. K INTO (PIO MU NEU GAM)/TOTAL(UNITS 10**-5)(P28)                 9/73
R42     0    6.1   OR LESS  CL=.90    LJUNG      73 HLBC +  EGAM GT 30 MEV    9/73

R43    CHAR. K INTO (E PIO NEU)/(PI PIO)                  (P6)/(P2)
R43  L 786    0.221      0.012        LUCAS2     73 HBC  -  DALITZ PRS ONLY  11/73
R43  L  LUCAS 73 GIVES N(E3)=786+-3.1PCT, N(PI2)=3564+-3.1PCT.  WE DIVIDE.   11/73
R43         . . . . . . . . . .
R43 FIT        0.2280    0.0031 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R44    CHAR. K INTO (PI 2PIO)/(PI PIO)                    (P4)/(P2)
R44  L 574    0.081      0.005        LUCAS2     73 HBC  -  DALITZ PRS ONLY  11/73
R44  L  LUCAS 73 GIVES N(PI 2PIO)=574+-5.9 PCT, N(PI2)=3564+-3.1 PCT.        11/73
R44  L  WE QUOTE 0.5*N(PI 2PIO)/N(PI2) WHERE 0.5 IS BECAUSE ONLY DALITZ      11/73
R44  L  PAIR PIO'S WERE USED.                                                11/73
R44         . . . . . . . . . .
R44 FIT        0.0819    0.0022 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R45    CHAR. K INTO(MU NEU GAMMA)/TOTAL  (UNITS 10**-3) (P12)                 7/74
R45     12    5.8        3.5          WEISSENBE 74 STRC +  E-GAMMA GT 9 MEV   7/74

R46    CHAR. K INTO (PI E+ E-)/(PI+ PI- E NEU) (UNITS 10**-3)  (P15)/(P7)
R46  B  41    7.0        1.3          BLOCH      75 SPEC +                   11/75
R46  B  BLOCH 75 QUOTES THIS RESULT MULTIPLIED BY OUR 1974 KE4 BR.FRAC.      11/75

R47    CHAR. K INTO (E NEU GAM)/(E NEU).                 (P21)/(P11)
R47     STRUCTURE DEPENDENT PART WITH + GAMMA HELICITY.
R47 H   56    (1.05)    (0.25)    (0.30) HEARD1     75 SPEC +  P(E) 236 TO 247 11/75
R47 H   THIS VALUE IS INCLUDED IN THE SECOND HEINTZE 79 VALUE IN SEC.R54     11/75
R47 H   BELOW.                                                               11/75

R48    K+ INTO (PI+-MU-+E+)/(PI+PI-E NEU) (UNITS 10**-4) (P25+P26)/(P7)      11/76
R48  D   0    1.9   OR LESS  CL=.90   DIAMANTBE 76 SPEC +                    11/76
R48  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR. RATIO.        11/76

R49    K+ INTO (PI+ MU+ E-)/(PI+PI- E NEU) (UNITS 10**-4)  (P29)/(P7)        11/76
R49  D   0    1.3   OR LESS  CL=.90   DIAMANTBE 76 SPEC +                    11/76
R49  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR RATIO.         11/76

R50    CHAR. K INTO (MU NEU E+E-)/(PI+PI-ENEU) (UNITS 10**-3) (P30)/(P7)     11/76
R50 D   14    (3.3)      (0.9)        DIAMANTBE 76 SPEC +  M(EE) GT 140      11/76
R50  D  14    27.        8.           DIAMANTBE 76 SPEC +  EXTRAPOLATED BR   11/76
R50  D  DIAMANTBE 76 QUOTES THESE RESULTS TIMES OUR 1975 KE4 BR RATIO.       11/76
R50  D  THE SECOND DIAMANTBE 76 VALUE IS THE FIRST VALUE EXTRAPOLATED TO 0   11/76
R50  D  TO INCLUDE LOW MASS E PAIRS.                                         11/76

R51    K+- INTO(PI-+E+-E+-)/(PI+PI-E NEU)  UNITS(10**-4) (P19)/(P7)          11/76
R51  D   0    2.5   OR LESS  CL=.90   DIAMANTBE 76 SPEC +                    11/76
R51  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 BR RATIO.             11/76

R52    K+- INTO(MU-+ NEU E+- E+-)/(PI+PI-E NEU)(UNITS 10**-3) (P31)/(P7)     11/76
R52  D   0    0.5   OR LESS  CL=.90   DIAMANTBE 76 SPEC +                    11/76
R52  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR RATIO.         11/76

R53    K+ INTO (NEU E+ E+ E-)/(PI+PI- E NEU) (UNITS 10**-2) (P32)/(P7)       11/76
R53      4    0.54       0.54      0.27 DIAMANTBE 76 SPEC +                  11/76
R53  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR RATIO.         11/76

R54    CHAR. K INTO (E NEU GAM)/(MU NEU)  (UNITS 10**-5)(P21)/(P1)
R54     STRUCTURE DEPENDENT PART WITH + GAMMA HELICITY
R54 H   51    (2.33)     (0.42)       HEINTZE    79 SPEC +                    7/79*
R54  H 107    2.40       0.36         HEINTZE    79 SPEC +                    7/79*
R54  H  SECOND HEINTZE 79 RESULT IS FIRST COMBINED WITH HEARD1 75 RESULT      7/79*
R54  H  FROM SECTION R47 ABOVE.                                               7/79*

R55    CHAR. K INTO (E NEU GAM)/(MU NEU)  (UNITS 10**-4)(P21)/(P1)
R55     STRUCTURE DEPENDENT PART WITH - GAMMA HELICITY
R55  H        1.6   OR LESS  CL=.90   HEINTZE    79 SPEC +                    7/79*
R55  H  IMPLIES (AXIAL VEC./VECTOR) AMPL. RATIO OUTSIDE RANGE -1.8 TO -.54.   7/79*

R56    CHAR. K INTO (E NEU NEU NEUBAR)/(E NEU)           (P33)/(P11)          7/79*
R56      0    3.8   OR LESS  CL=.90   HEINTZE    79 SPEC +                    7/79*
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Note on Slope Parameter for $K \to 3\pi$ Decays

As was discussed in Section VI B.1 of the text, for the 3π decays of the K mesons we list the slope parameter "g" which is defined, as in that section, by

$$|M|^2 \propto 1 + g\,\frac{(s_3 - s_0)}{m_{\pi+}^2} + h\left(\frac{s_3 - s_0}{m_{\pi+}^2}\right)^2 + j\,\frac{(s_2 - s_1)}{m_{\pi+}^2} + k\left(\frac{s_2 - s_1}{m_{\pi+}^2}\right)^2 + \ldots, \qquad (1)$$

where

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For notation, see key at front of Listings.

$K^{\pm}$

$$s_i = (\underline{p}_K - \underline{p}_i)^2 = (m_K - m_i)^2 - 2m_K T_i \qquad (2)$$

$$s_0 = \frac{1}{3}\sum s_i = \frac{1}{3}(m_K^2 + m_1^2 + m_2^2 + m_3^2) \qquad (3)$$

$\underline{p}_K$, $\underline{p}_i$ are the four-vectors for the K and the i^{th} pion, and the index 3 refers to the odd pion, i.e., the third pion in the decays listed below. (4)

We refer to the three possible charged decays as τ, τ', and τ^0:

$\tau^{\pm}$ $\quad K^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}$

$\tau'^{\pm}$ $\quad K^{\pm} \to \pi^0\pi^0\pi^{\pm}$

τ^0 $\quad K_L^0 \to \pi^+\pi^-\pi^0$

The measurements of g vary considerably beyond the authors' quoted errors as can be seen in the ideograms associated with the GT+, GT-, and GTP subsections of the $K^{\pm}$ Data Card Listings and the GT0 subsection of the K_L^0 Listings. Appendix I discusses tests of the $\Delta I = 1/2$ rule utilizing these slopes.

There is no indication of a CP-violating asymmetry in K_L^0 decay as measured by the coefficient j given in subsection JT0 of the K_L^0 Listings.

The high-statistics τ^0-decay experiment of MESSNER 74 finds significant non-zero quadratic coefficients h and k. CHO 77, a lower-statistics τ^0 experiment, obtains results in agreement with MESSNER 74 but can also obtain good fits with a linear term (g) only. The correlation between the linear and quadratic coefficients changes the CHO 77 g_{τ^0} from 0.629 ± 0.017 (linear fit) to 0.681 ± 0.024 (quadratic fit). Another experiment, PEACH 77, does not observe this correlation and is in agreement only with the linear fit of CHO 77.

There is some evidence for a non-zero k coefficient from $\tau^{\pm}$ experiments. FORD 72 (1.5M events) have studied $K^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}$ and find that the χ^2/DF goes from 1.38 to 1.20 for DF ≈ 150 when the second order and CP-violation terms are added. However, the authors state that since their Coulomb correction is larger than the experimental errors and is not well known, it is difficult to interpret these results. DEVAUX 77 also finds a non-zero k.

Because of the above evidence for quadratic terms, and for consistency in our treatment of τ^0 and $\tau^{\pm}$ decay, we now include in our averages only those τ^0 and $\tau^{\pm}$ experiments for which we have information on the three coefficients g, h, and k. Correlations prevent us from comparing fits which do not include these three parameters. For $\tau'^{\pm}$ decays we compile g and h only since no experiments measure k.

Parametrizations

In the literature *other definitions* of slope parameters have appeared. We have converted to the definitions of g, h, j and k in Eq. (1) from whatever experimental quantity has been reported. We give the conversion to the definition (1) for the most widely used parametrizations and tabulate the conversion factors for the reader's convenience.

a) For analysis of charged K's and some K^0 experiments, the expression often used is:

$$|M|^2 = 1 + a_Y Y + b_Y Y^2 + d_Y X + e_Y X^2$$

with

$$Y = \frac{3T_3 - Q}{Q},$$

$$X = \frac{\sqrt{3}\,(T_1 - T_2)}{Q},$$

$$Q = m_K - \sum m_i \quad .$$

The relevant formulae are:

$$Y = -\frac{3}{2}\,\frac{s_3 - s_0}{m_K Q} + \Delta\,, \qquad X = \frac{\sqrt{3}}{2}\,\frac{s_2 - s_1}{m_K Q}$$

with

$$\Delta = \frac{m_1 - m_3}{Q}\left(2 - \frac{m_3 + m_1}{m_K}\right)$$

and

$$g = \frac{-c_y(a_y + 2b_y\Delta)}{1 + a_y\Delta + b_y\Delta^2} ,$$

$$h = \frac{c_y^2 b_y}{1 + a_y\Delta + b_y\Delta^2} ,$$

$$j = \frac{c_y d_y}{\sqrt{3}\,(1 + a_y\Delta + b_y\Delta^2)} ,$$

$$k = \frac{c_y^2 e_y}{3(1 + a_y\Delta + b_y\Delta^2)} ,$$

with

$$c_y = \frac{3}{2}\frac{m_{\pi^+}^2}{m_K Q} .$$

b) For the analysis of some K^0 experiments the expression used is

$$|M|^2 = 1 + 2a_t \frac{m_K}{m_{\pi^+}^2}(2T_3 - T_{3max}) + b_t\left(\frac{m_K}{m_{\pi^+}^2}\right)^2 (2T_3 - T_{3max})^2 ,$$

with

$$T_{3max} = \frac{(m_K - m_3)^2 - (m_1 + m_2)^2}{2m_K} .$$

The relevant transformations are

$$T_3 = -\frac{s_3 - s_0}{2m_K} + \frac{Q}{3}(1+\Delta)$$

and

$$g = \frac{-2a_t - b_t c_t}{1 + a_t c_t + \frac{b_t c_t^2}{4}} ,$$

$$h = \frac{b_t}{1 + a_t c_t + \frac{b_t c_t^2}{4}} ,$$

with

$$c_t = \frac{2m_K}{m_{\pi^+}^2}\left[\frac{2}{3}Q(1+\Delta) - T_{3max}\right] .$$

c) Other K^0 authors use the same form of matrix element as given in b) above with a linear term only, but define

$$T_{max} = \frac{2}{3}Q .$$

The relevant transformation is then

$$g = \frac{-2a_u}{1 + a_u c_u} ,$$

with

$$c_u = \frac{4m_K}{3m_{\pi^+}^2} Q\Delta .$$

d) Older K^0 analyses were done using

$$|M|^2 = 1 + a_v \frac{T_3}{m_K} .$$

The relevant transformation is then

$$g = \frac{-c_v a_v}{1 + d_v a_v} ,$$

with

$$c_v = \frac{m_{\pi^+}^2}{2m_K^2}$$

and

$$d_v = \frac{Q}{3m_K}(1+\Delta) .$$

e) The CP-violating term in $|M|^2$ for $K_L^0 \to \pi^+\pi^-\pi^0$ experiments has been parametrized in several ways. BLANPIED 68 and SCRIBANO 70 use the parametrization given in (b) above with no quadratic term and with an additional CP violating term. BLANPIED 68 parametrizes the CP-violating term as

$$2\sigma_B \frac{m_K}{m_{\pi^+}^2}(T_1 - T_2) .$$

The relevant transformation is then

$$j = \frac{\sigma_B}{1 + c_t a_t}$$

with c_t as defined in (b) above. SCRIBANO 70 parametrizes the CP-violating term as

$$\frac{2}{\sqrt{3}}\,\sigma_S\,\frac{T_1 - T_2}{T_{12max}}$$

where T_{12max} is the maximum kinetic energy of particle 1 or 2, the charged π's, given by

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Data Card Listings

For notation, see key at front of Listings.

$$T_{12max} = \frac{(m_K - m_1)^2 - (m_2 + m_3)^2}{2m_K} .$$

The resulting transformation is then

$$\boxed{j = \frac{m_{\pi^+}^2}{\sqrt{3}\, m_K\, T_{12max}} \; \frac{\sigma_s}{(1 + c_t a_t)}} .$$

SMITH 70 gives the asymmetry

$$\alpha = \frac{N_+ - N_-}{N_+ + N_-}$$

where N_+ is the number of events with $T_1 > T_2$ and N_- is the converse. BLANPIED 68 gives the relation $\sigma_B = \alpha/1.16$ which allows us to use the transformation to j given above for BLANPIED 68.

For the reader's convenience we give a table of numerical values for Q, T_{3max}, T_{12max}, Δ, c_y, c_t, c_u, c_v, and d_v, obtained using the masses from the current edition.

	$\tau^{\pm}$	$\tau'^{\pm}$	τ^0
Q	74.97	84.18	83.57
T_{3max}	48.08	53.20	53.89
T_{12max}	48.08	53.99	53.12
Δ	0.0000	−0.0790	0.0798
c_y	0.7895	0.7031	0.7025
c_t	0.0962	−0.0769	0.3204
c_u	0.0000	−0.2247	0.2272
c_v	0.0400	0.0400	0.0393
d_v	0.0506	0.0523	0.0604

References

See the reference sections of the $K^{\pm}$ and K_L^0 Data Card Listings.

See also the review of T. J. Devlin and J. O. Dickey, Rev. Mod. Phys. 51, 237 (1979), ~~which~~ contains an analysis of $K \rightarrow 2\pi$ and $K \rightarrow 3\pi$ data in terms of transition amplitudes with appropriate energy dependence.

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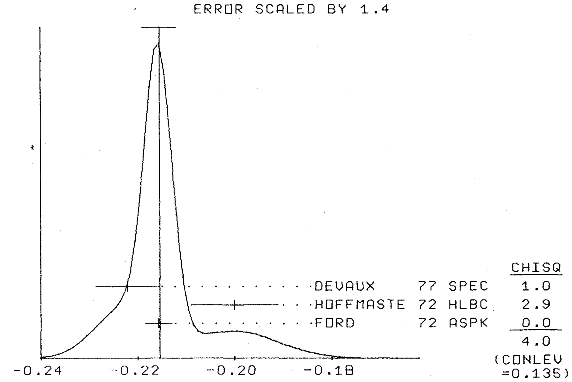
          10  CHARGED K ENERGY DEPENDENCE OF DALITZ PLOT

      RELATED TEXT SECTION VI B.1, APPENDIX I, AND MINI-REVIEW ABOVE

    MATRIX ELEMENT SQUARED = 1 + G*U + H*U**2 + K*V**2                   1/79*
    WHERE U=(S3-S0)/(MPI**2) AND V=(S1-S2)/(MPI**2)                      1/79*

GT+     LINEAR COEFFICIENT G FOR TAU DECAYS K+ --> PI+ PI+ PI-           1/79*
GT+        SOME  EXPTS USE DALITZ VARIABLES X AND Y. WE GIVE AY=COEFF OF Y  1/79*
GT+        TERM AT RIGHT. SEE MINI-REVIEW ABOVE.                         1/79*
GT+ZL 5428  (-0.22)    (0.024)        ZINGHENKO 67 HBC  +  AY=0.28+-.03      10/69
GT+ L 9994  (-0.218)   (0.016)        BUTLER    68 HBC  +  AY=0.277+-.020    10/69
GT+ G17898  (-0.196)   (0.012)        GRAUMAN   70 HLBC +  AY=0.228+-.030     8/70
GT+   750K   -0.2157    0.0028        FORD      72 ASPK +  AY=0.2734+-.0035  1/79*
GT+H 39819   -0.200     0.009         HOFFMASTE 72 HLBC +                    1/79*
GT+   225K   -0.2221    0.0065        DEVAUX    77 SPEC +  AY=0.2814+-.0082  1/79*
GT+ L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.           3/78
GT+ Z   ALSO INCLUDES DBC EVENTS
GT+ G   EMULS. DATA ADDED - ALL EVENTS INCLUDED BY HOFFMASTER 72          1/71
GT+H    HOFFMASTER 72 INCLUDES GRAUMAN 70 DATA.                          1/79*
GT+         . . . . . . . . .
GT+ AVG      -0.2154    0.0035  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
GT+ STUDENT  -0.2156    0.0028  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                (SEE IDEOGRAM BELOW )
```

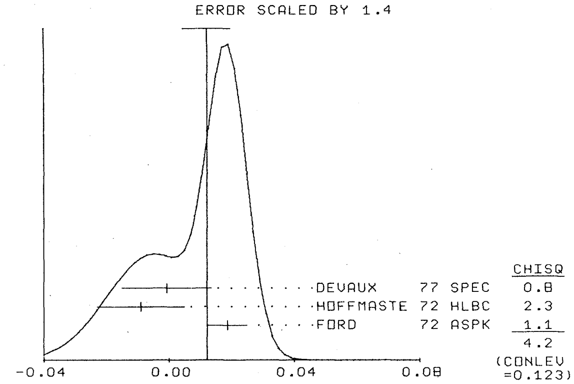
WEIGHTED AVERAGE = −0.2154 ± 0.0035
ERROR SCALED BY 1.4



LIN. ENERGY DEP. FOR K+ TO PI+ PI+ PI−

```
HT+     QUADRATIC COEFF. H FOR K+ --> PI+ PI+ PI-                        1/79*
HT+   750K    0.0187    0.0062        FORD      72 ASPK +                1/79*
HT+  39819   -0.009     0.014         HOFFMASTE 72 HLBC +                1/79*
HT+   225K   -0.0006    0.0143        DEVAUX    77 SPEC +                1/79*
HT+         . . . . . . . . .
HT+ AVG       0.0122    0.0076  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
HT+ STUDENT   0.0124    0.0065  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.0122 ± 0.0076
ERROR SCALED BY 1.4



QUAD. COEFF. H FOR K+ --› PI+ PI+ PI−

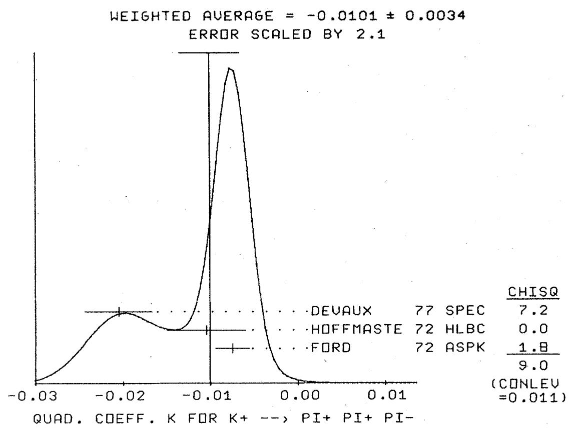
```
KT+     QUADRATIC COEFF. K FOR K+ --> PI+ PI+ PI-                        1/79*
KT+   750K   -0.0075    0.0019        FORD      72 ASPK +                1/79*
KT+  39819   -0.0105    0.0045        HOFFMASTE 72 HLBC +                1/79*
KT+   225K   -0.0205    0.0039        DEVAUX    77 SPEC +                1/79*
KT+         . . . . . . . . .
KT+ AVG      -0.0101    0.0034  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
KT+ STUDENT  -0.0094    0.0021  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                (SEE IDEOGRAM BELOW )
```

Data Card Listings

For notation, see key at front of Listings.

Stable Particles

$K^{\pm}$



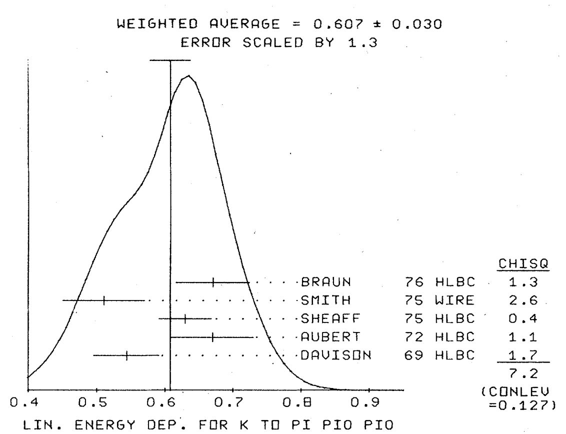

```
GT-      LINEAR COEFFICIENT G FOR TAU DECAYS K- --> PI- PI- PI+
GT-         FOR DEFINITION OF AY SEE NOTE IN SECTION GT+ ABOVE.
GT- F 1347  (-0.220)  (0.035)          FERRO-LUZ 61 HBC   - AY=0.28+-.045      10/69
GT-ML 5778  (-0.190)  (0.023)          MOSCOSO   68 HBC   - AY=0.242+-.029     10/69
GT-  50919   -0.193    0.010           MAST      69 HBC  -  AY=0.244 +-.013     1/79*
GT-   750K   -0.2186   0.0028          FORD      72 ASPK -  AY=0.2770+-.0035    1/79*
GT- Q  81K  (-0.199)  (0.008)          LUCAS1    73 HBC   - AY=0.252+-.011     10/72
GT- F   NO RADIATIVE CORRECTIONS INCLUDED.
GT- L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.                  3/78
GT- M   ALSO INCLUDES DBC EVENTS.
GT- Q  QUADRATIC DEPENDENCE IS REQUIRED BY KL EXPTS.  FOR COMPARISON WE          1/79*
GT- Q  AVERAGE ONLY THOSE K+- EXPERIMENTS WHICH QUOTE QUADRATIC FIT VALUES.     1/79*
GT-         . . . . . . . . .
GT- AVG        -0.2167   0.0066  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.5)
GT- STUDENT    -0.2173   0.0031  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

HT-      QUADRATIC COEFF H FOR K- --> PI- PI- PI+                               1/79*
HT-  50919   -0.001    0.012           MAST      69 HBC  -                      1/79*
HT-   750K    0.0125   0.0062          FORD      72 ASPK -                      1/79*
HT-         . . . . . . . . .
HT- AVG         0.0097   0.0055  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
HT- STUDENT     0.0098   0.0061  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

KT-      QUADRATIC COEFF K FOR K- --> PI- PI- PI+                               1/79*
KT-  50919   -0.014    0.012           MAST      69 HBC  -                      1/79*
KT-   750K   -0.0083   0.0019          FORD      72 ASPK -                      1/79*
KT-         . . . . . . . . .
KT- AVG        -0.0084   0.0019  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
KT- STUDENT    -0.0084   0.0020  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

DG  ((GT+)-(GT-))/((GT+)+(GT-)) IN PERCENT
DG       A NON-ZERO VALUE FOR THIS QUANTITY INDICATES CP VIOLATION
DG    3.2M   -0.70     0.53            FORD      70 ASPK                       11/70

GTP      LINEAR COEFFICIENT G FOR TAU PRIME DECAYS CHAR. K --> PI PIO PIO.
GTP      UNLESS OTHERWISE STATED, ALL EXPTS INCLUDE TERMS QUADRATIC IN
GTP      (S3-S0)/(MPI**2). SEE MINI-REVIEW ABOVE.
GTP K 1792   (0.48)   (0.04)           KALMUS    64 HLBC +                      1/79*
GTP K 1874   (0.586)  (0.098)          BISI      65 HLBC +  ALSO HBC            1/79*
GTP   4048    0.544    0.048           DAVISON   69 HLBC +  ALSO EMUL           1/79*
GTP L  198   (0.527)  (0.102)          PANDOULAS 70 EMUL +                      1/79*
GTP   1365    0.67     0.06            AUBERT    72 HLBC +                      1/79*
GTP K  574   (0.484)  (0.084)          LUCAS2    73 HBC  -  DALITZ PRS ONLY     1/79*
GTP   5635    0.630    0.038           SHEAFF    75 HLBC +                      1/79*
GTP    27K    0.510    0.060           SMITH     75 WIRE +                      1/79*
GTP L 4639   (0.806)  (0.220)          BERTRAND  76 EMUL +                      1/79*
GTP   3263    0.670    0.054           BRAUN     76 HLBC +                      1/79*
GTP K   AUTHORS GIVE LINEAR FIT ONLY.
GTP L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.
GTP         . . . . . . . . .
GTP AVG         0.607    0.030   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
GTP STUDENT     0.610    0.027   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )
```




```
HTP      QUADRATIC COEFF H FOR CHAR K --> PI PIO PIO. SEE MINI-REVIEW ABOVE.
HTP   4048    0.026    0.050           DAVISON   69 HLBC +  ALSO EMUL           1/79*
HTP L  198   (0.018)  (0.124)          PANDOULAS 70 EMUL +                      1/79*
HTP   1365   -0.01     0.08            AUBERT    72 HLBC +                      1/79*
HTP   5635    0.041    0.030           SHEAFF    75 HLBC +                      1/79*
HTP    27K    0.009    0.040           SMITH     75 WIRE +                      1/79*
HTP L 4639   (0.164)  (0.121)          BERTRAND  76 EMUL +                      1/79*
HTP   3263    0.152    0.082           BRAUN     76 HLBC +                      1/79*
HTP L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.                  1/79*
HTP         . . . . . . . . .
HTP AVG         0.034    0.020   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
HTP STUDENT     0.033    0.022   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
```

------ --------- --------- --------- --------- --------- --------- --------

Note on $K^{\pm}_{\ell 3}$ and $K^{0}_{\ell 3}$ Form Factors

Definitions of the parameters λ_+, $\xi(0)$, λ_0, $|f_S/f_+|$ and $|f_T/f_+|$ and a general discussion of the methods of analysis are given in Section VI B.2 of the text.

This note describes the contents of the Data Card Listings for the two $K_{\mu 3}$ parametrizations, $(\lambda_+, \xi(0))$ and (λ_+, λ_0), which were discussed in the text. Problems related to our data entries for individual experiments are discussed and a comparison of results is given.

$K_{\mu 3}$ Experiments

The matrix element for $K_{\mu 3}$ decay, assuming a pure vector current, is given by Eq. (2) in Section VI B.2 of the text. Most experiments appear to be compatible with the assumption that f_+ depends linearly on t and that f_- is constant. Only DALLY 72 ($K^0_{\mu 3}$) appears to require $\lambda_- \neq 0$ (by about three standard deviations). A single data bin at low q^2 seems to be responsible. The effect is not observed in the high-statistics experiment of DONALDSON2 74 (also $K^0_{\mu 3}$).

λ_+, $\xi(0)$ Parametrization: λ_+ data from $K_{\mu 3}$ decay are entered into the $K^{\pm}$ and K^0_L sections of the Data Card Listings in subsection L+M. The corresponding $\xi(0)$ values are entered in subsection XIA, XIB, or XIC, depending on whether Method A, B, or C, discussed below and in the text, was used. The data cards contain the values, one-standard-deviation errors $\Delta\lambda_+$ and $\Delta\xi(0)$, as well as the correlation $d\xi(0)/d\lambda_+$, all indicated on the $e^{-1/2}$ likelihood contour below. The correlations are given on the right side of the $\xi(0)$ data cards.

λ_+, λ_0 Parametrization: This parametrization is used in recent $K_{\mu 3}$ analyses. To facilitate comparison between experiments, we convert earlier experiments from the $(\lambda_+, \xi(0))$ parametrization to (λ_+, λ_0) whenever possible (i.e., when λ_+ and $\xi(0)$ values, errors, and correlations are given). The

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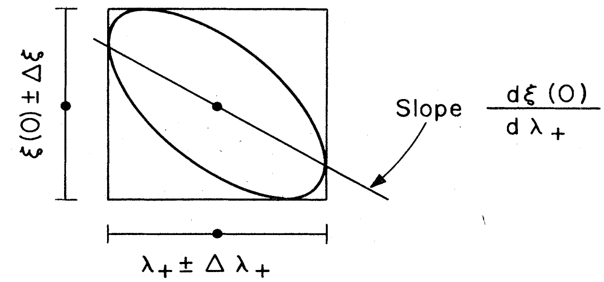
$K^{\pm}$

Data Card Listings

For notation, see key at front of Listings.



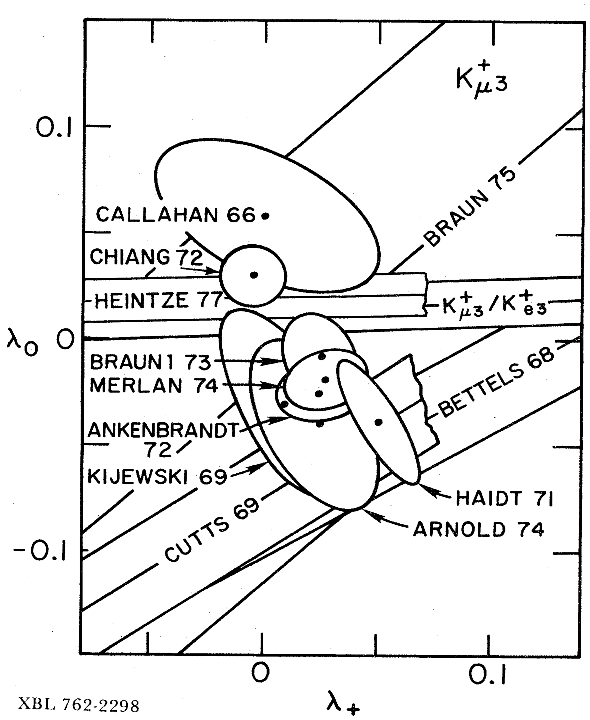
transformation between these parametrizations is:

$$\lambda_0 = \lambda_+ + a\xi(0) \ ,$$

$$\Delta\lambda_0^2 = (1 + 2a\,\frac{d\xi(0)}{d\lambda_+})\,\Delta\lambda_+^2 + a^2\Delta\xi^2 \ ,$$

$$\frac{d\lambda_0}{d\lambda_+} = 1 + a\,\frac{d\xi(0)}{d\lambda_+} \ ,$$

where $a = m_\pi^2/(m_K^2 - m_\pi^2)$. The λ_0 value, the one-standard-deviation error $\Delta\lambda_0$, and the correlation $d\lambda_0/d\lambda_+$ are given in subsection L0 of the data cards.



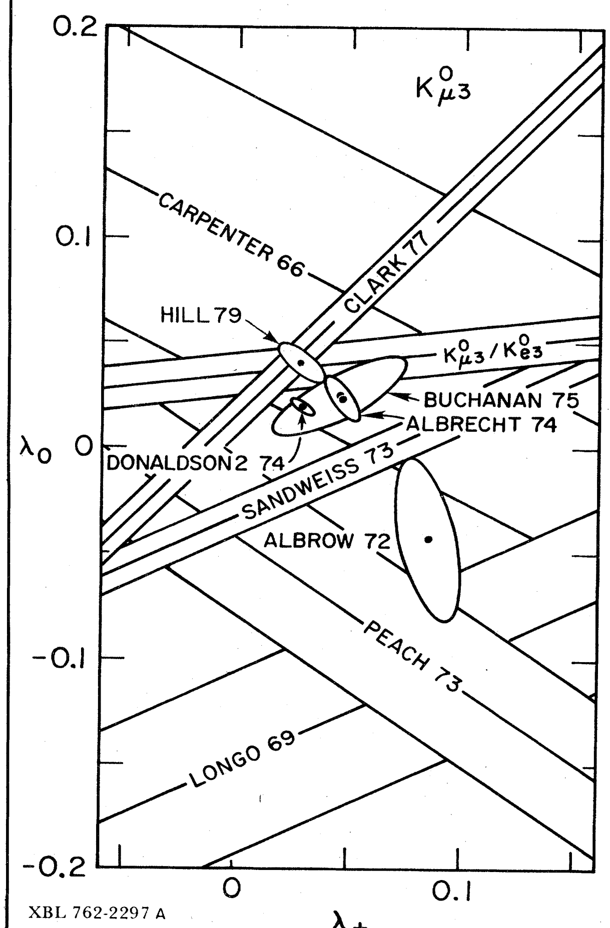
XBL 762-2298

Fig. 1. One-standard-deviation ($e^{-1/2}$) likelihood contours in the (λ_+,λ_0) plane for $K^+_{\mu3}$.

We also convert (λ_+,λ_0) results into the $(\lambda_+, \xi(0))$ parametrization whenever possible so that subsection L0 is essentially equivalent to the three subsections XIA, XIB, and XIC.

Individual analyses have used a variety of parametrizations. Problems arise when trying to express their results in terms of the parametrizations used here. The discussion of these problems is divided into three sections corresponding to the three methods of analyses discussed in the text.

Method A: Dalitz plot analyses and pion spectrum analyses usually determine λ_+ and $\xi(0)$ (or λ_0) values, errors, and correlation. Such measurements are entered in the L+M, XIA, and L0 subsections. They give rise to the error ellipses shown in Figs. 1 and 2. These are approximations to likelihood contours.



XBL 762-2297 A

Fig. 2. One-standard-deviation ($e^{-1/2}$) likelihood contours in the (λ_+,λ_0) plane for $K^0_{\mu3}$.

Data Card Listings

For notation, see key at front of Listings.

Stable Particles

$K^{\pm}$

Some analyses of this type fix λ_+ and determine $\xi(0)$, e.g., CARPENTER 66 and PEACH 73 (both $K^0_{\mu 3}$). We enter $\xi(0)$ and $d\xi(0)/d\lambda_+$ in the XIA section and give the fixed λ_+ value in the data card footnote. The $\xi(0)$ error is parenthesized because it does not include the uncertainty in the value of λ_+. These results, transformed to λ_0 measurements, give rise to bands in Fig. 2. These bands are also approximations to the likelihood contours. The actual likelihood bands would not be straight.

In some cases, we alter an error from its published value in order to obtain an error ellipse with a width which matches the error in $\xi(0)$ for fixed λ_+. These adjustments are noted in the $\xi(0)$ data card footnotes, e.g., for CALLAHAN1 66 and HAIDT 71 (K^+ subsection XIA), where the published errors and correlation violate the constraint $|C_{\lambda\xi}| < 1$ on the normalized correlation coefficient $C_{\lambda\xi}$ given by

$$C_{\lambda\xi} = \frac{\Delta\lambda_+}{\Delta\xi} \frac{d\xi(0)}{d\lambda_+} .$$

In some cases, e.g., BRAUN1 73, the parametrization used is λ_+, $\xi(0)$, $\xi(t^*)$, where t^* is the weighted average of t with weighting according to the sensitivity to ξ. In this case we do not use $\xi(0)$. It is a badly determined parameter comparable to λ_- or the slope of $\xi(t)$. Instead, we use

$$\xi(0) = \xi(t^*)(1 + \lambda_+ t^*) ,$$

$$\frac{d\xi(0)}{d\lambda_+} = \frac{d\xi(t^*)}{d\lambda_+}(1 + \lambda_+ t^*) + \xi(t^*)t^* .$$

With the BRAUN1 73 values, $\lambda_+ = 0.027$, $\xi(6.6) = -0.34 \pm 0.20$, and $d\xi(6.6)/d\lambda_+ = -14$, we obtain

$$\xi(0) = (-0.40 \pm 0.24) - 19(\lambda_+ - 0.027) ;$$

or for their fitted $\lambda_+ = 0.025 \pm 0.017$, we get $\xi(0) = -0.36 \pm 0.40$.

Method B: Branching ratio experiments cannot determine λ_+ and $\xi(0)$ simultaneously, but simply fix a relationship between them, given in Section VI B.2 of the text. Results are usually quoted as values of $\xi(0)$ at fixed λ_+. We list these results in subsection XIB, but we do not average them because the λ_+ values differ. Instead, we compute a combined result by using the relations in the text and our fitted values of $\Gamma(K^{\pm}_{\mu 3})/\Gamma(K^{\pm}_{e3})$ and $\Gamma(K^0_{\mu 3})/\Gamma(K^0_{e3})$, which include the branching ratios from these experiments. The branching ratios from our current edition and the results for $\xi(0)$ and λ_0 evaluated at $\lambda_+ = 0.030$ are

	$K^{\pm}$	K^0_L
$\Gamma(K_{\mu 3})/\Gamma(K_{e3})$	0.663 ± .018 (S=1.7)	0.695 ± .017
$\xi(0)$	−0.20 ± .15 (S=1.7)	+0.08 ± .13
$d\xi(0)/d\lambda_+$	−11.9	−10.3
λ_0	+0.014 ± .012 (S=1.7)	+0.037 ± .011
$d\lambda_0/d\lambda_+$	+0.04	+0.12

The scale factor S is the amount by which the error has been multiplied in order to compensate for discrepancies in the branching ratios. These λ_0 results give rise to the $K_{\mu 3}/K_{e3}$ bands in Figs. 1 and 2.

Method C: Polarization experiments measure $\langle\xi(t)\rangle$, the weighted average of $\xi(t)$ over the t range of the experiment, where the weighting accounts for the variation with t of the sensitivity to $\xi(t)$. Such measurements are entered in subsection XIC.

To reinterpret these results in the $(\lambda_+, \xi(0))$ parametrization, we recognize that $\lambda_+ = 0$ corresponds to $\xi(t)$ constant (always assuming $\lambda_- = 0$) so that

$$\xi(0)\Big|_{\lambda_+=0} \equiv \langle\xi(t)\rangle .$$

The correlation with λ_+ is given by the following relations (valid for small λ_+):

$$\xi(0) \approx \langle\xi(t)\rangle\left(1 + \lambda_+\left\langle\frac{t}{m_\pi^2}\right\rangle\right) ,$$

$$\frac{d\xi(0)}{d\lambda_+} \approx \langle\xi(t)\rangle\left\langle\frac{t}{m_\pi^2}\right\rangle ,$$

where $\langle t/m_\pi^2\rangle$ is the average value of t weighted by the sensitivity to $\xi(t)$. These results, transformed to λ_0 and $d\lambda_0/d\lambda_+$ values, are entered in subsection L0 and give rise to bands in Figs. 1 and 2.

In Figs. 1 and 2, we disregard those polarization measurements for which $d\xi(0)/d\lambda_+$ is not

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$K^{\pm}$

obtainable. Also we disregard MERLAN 73 because the signs of $\xi(0)$ and $d\xi(0)/d\lambda_+$ are opposite, whereas the above equation requires them to be the same (since $t > 0$).

Comparison of $K_{\mu 3}$ Experiments: Figures 1 and 2 show the likelihood contours in the (λ_+, λ_0) plane for $K^+_{\mu 3}$ and $K^0_{\mu 3}$ respectively.

The $K^+_{\mu 3}$ Dalitz plot results (ellipses) shown are fairly consistent and appear to cluster between the $K_{\mu 3}/K_{e3}$ result and the polarization results of BETTELS 68 and CUTTS 69. The $K^0_{\mu 3}$ results are much less consistent with a small cluster appearing in the neighborhood of the DONALDSON2 74 result.

χ^2 fits to the results shown in Fig. 1 and Fig. 2 yield the following values for λ_+ and λ_0. The corresponding values of $\xi(0)$ are also given.

	$K^+_{\mu 3}$	$K^0_{\mu 3}$
λ_+	$+0.026 \pm 0.008^*$	$+0.034 \pm 0.005^*$
λ_0	$-0.003 \pm 0.007^*$	$+0.022 \pm 0.006^*$
$d\lambda_0/d\lambda_+$	-0.11	-0.30
χ^2/DF	40/19	76/14
S^*	1.5	2.3
. . . .	. . . .	. . . .
$\xi(0)$	$-0.35 \pm 0.14^*$	-0.14 ± 0.11
$d\xi(0)/d\lambda_+$	$-14.$	$-15.$

*All errors have been increased by the scale factor $S = (\chi^2/\mathrm{DF})^{1/2}$ to take into account the discrepancies between measurements.

In view of the large χ^2/DF of these fits, especially $K^0_{\mu 3}$, the fit results should be taken with a grain of salt. The largest contributors to χ^2 in the $K^+_{\mu 3}$ case are CHIANG 72 with 8.1, and the polarization results, BETTELS 68 with 6.8 and CUTTS 69 with 5.5. In the $K^0_{\mu 3}$ case the largest contributors are the polarization results of SANDWEISS 73 with 18, LONGO 69 with 14, and CLARK 77 with 10, and the Dalitz plot results of ALBROW 72 with 11, ALBRECHT 74 with 5.9, and PEACH 73 with 5.5. All other χ^2 values were less than 5.

The DONALDSON2 74 result

$$\lambda_+ = 0.030 \pm 0.003$$

$$\lambda_0 = 0.019 \pm 0.004$$

clearly dominates the statistics in the $K^0_{\mu 3}$ case. The λ_+ value is consistent with the K_{e3} value of λ_+, and with the pole approximation

$$f_+(t) = f_+(0)\,\frac{m^2_{K^*}}{m^2_{K^*} - t} \;.$$

Their $f_0(t)$ extrapolates linearly to the Callan-Treiman point. It is less than two standard deviations from the $K_{\mu 3}/K_{e3}$ result.

K_{e3} Experiments

The f_- term of the matrix element [Eq. (2) text Section VI B.2] can be neglected for K_{e3} because it is proportional to the lepton mass. The f_+ term is usually assumed to be linear in $t = q^2 = (P_K - P_\pi)^2$, the square of the four-momentum transfer, i.e., the effective mass of the lepton pair. We quote the linear coefficient λ^e_+ (L+E on the data cards). There has been some suggestion of departure from linearity [CHIEN 71 (K^0_{e3}) and Chounet, Gaillard, and Gaillard[1] — Review] but no compelling evidence. The λ_+ results are fairly consistent and the average values are

$$K^+_{e3}: \quad \lambda_+ = 0.0285 \pm 0.0043$$

$$K^0_{e3}: \quad \lambda_+ = 0.0301 \pm 0.0016 \quad (S = 1.2)$$

where the K^0_{e3} error has been multiplied by the scale factor 1.2 to compensate for inconsistencies (see ideogram in K^0_L section L+E).

See also the excellent reviews of Gaillard and Chounet,[1] Chounet, Gaillard, and Gaillard,[2] and Pondrom.[3]

References

1. M. K. Gaillard and L. M. Chounet, "$K_{\ell 3}$ Form Factors," CERN 70-14 (May 1970), and Phys. Letters 32B, 505 (1970).
2. L. M. Chounet, J. M. Gaillard, and M. K. Gaillard, Physics Reports 4C, 199 (1972).
3. L. G. Pondrom, "Weak Decay Processes," Proc. Particles and Fields 1976, BNL, Oct. 6-8, 1976.

Data Card Listings

For notation, see key at front of Listings.

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$K^{\pm}$

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              10  CHARGED K FORM FACTORS

      RELATED TEXT SECTION VI B.2 AND MINI-REVIEW ABOVE.

      IN THE FORM FACTOR COMMENTS, THE FOLLOWING ABBREVIATIONS ARE USED.
      F+ AND F- ARE FORM FACTORS FOR THE VECTOR MATRIX ELEMENT.
      FS AND FT REFER TO THE SCALAR AND TENSOR TERM.
      F0 = (F+) + (F-)*T/(MK**2-MPI**2)
      L+, L- AND LO ARE THE LINEAR EXPANSION COEFFS. OF F+, F- AND F0.
      L+ REFERS TO THE KMU3 VALUE EXCEPT IN THE KE3 SECTIONS.
      DXI/DL IS THE CORRELATION BETWEEN XI(0) AND L+ IN KMU3.
      DLO/DL+ IS THE CORRELATION BETWEEN LO AND L+ IN KMU3.
      T   = MOMENTUM TRANSFER TO THE PI IN UNITS OF MPI**2.
      DP  = DALITZ PLOT ANALYSIS
      PI  = PI  SPECTRUM ANALYSIS
      MU  = MU SPECTRUM ANALYSIS
      POL= MU POLARIZATION ANALYSIS
      BR  = KMU3/KE3 BRANCHING RATIO ANALYSIS
      E   = POSITRON OR ELECTRON SPECTRUM ANALYSIS
      RC  = RADIATIVE CORRECTIONS

XIA     XIA = F-/F+ (DETERMINED FROM SPECTRA)    ----------------------------
XIA      76  (+1.8)     (0.6)               BROWN     62 XEBC +  DP+BR, L+=0        1/74
XIA      87  (+0.7)     (0.5)               GIACOMELL 64 EMUL +  MU+BR RVUE, L+=0   1/74
XIA J        (-0.08)    (0.7)               JENSEN    64 XEBC +  DP+BR(KMU3,KE3)    1/74
XIA    2648   (0.0)     (1.1)      (0.9)    CALLAHA1  66 FRBC +  MU, L+=0, T UNKN   1/74
XIA  C 444   +0.72       0.93               CALLAHA1  66 FRBC +  PI, DXI/DL=-17     1/74
XIA      78  (-0.5)     (0.9)               EISLER    68 HLBC +  PI,L+=0,NO DX/DL   1/74
XIA  K2041   -0.5        0.8                KIJEWSKI  69 OSPK +  PI, DXI/DL=-26     1/74
XIA  H3240   -1.1        0.56               HAIDT     71 HLBC +  DP, DXI/DL=-29     1/74
XIA  A4025   -0.62       0.28               ANKENBRAN 72 ASPK +  PI, DXI/DL=-12     1/74
XIA  B3480   +0.45       0.28               CHIANG    72 OSPK +  DP, DXI/DL=-15     1/74
XIA  D1897   -0.36       0.40               BRAUN1    73 HLBC +  DP, DXI/DL=-19     3/74
XIA  N 490   -0.8        0.8                ARNOLD    74 HLBC +  DP, DXI/DL=-20    11/75
XIA  M6527   -0.57       0.24               MERLAN    74 ASPK +  DP, DXI/DL= -9     3/74
XIA J   JENSEN 64 GIVES L+M=L+E=-.020+-.027. DXI/DL UNKNOWN. INCLUDES             1/74
XIA J   SHAKLEE 64 XIB(KMU3/KE3).                                                  1/74
XIA  C  CALLAHAN 66 TABLE 1 (PI ANAL) GIVES DXI/DL=(.72-.05)/(0-.04)=-17,         1/74
XIA  C  ERROR RAISED FROM .80 TO AGREE WITH DXI0=.37 FOR FIXED L+.                1/74
XIA  K  KIJEWSKI 69 FIG. 17 WAS USED TO OBTAIN DXI/DL AND ERRORS.                 1/74
XIA  H  HAIDT 71 TABLE 8 (DP ANAL) GIVES DXI/DL=(-1.1+0.5)/(.050-.029)=-29,       1/74
XIA  H  ERROR RAISED FROM .50 TO AGREE WITH DXI0=.20 FOR FIXED L+.                1/74
XIA  A  ANKENBRANDT 72 FIG. 3 WAS USED TO OBTAIN DXI/DL.                          1/74
XIA  B  CHIANG 72 FIG. 10 WAS USED TO OBTAIN DXI/DL.                              1/74
XIA  B  FIT HAD L-=L+ BUT WOULD NOT CHANGE FOR L-=0.  L.PONDROM,PRIV.COM.74       1/74
XIA  D  BRAUN1 73 GIVES XI(T)=-.34+-.20, DXI(T)/DL+=-14 FOR L+=.027, T=6.6.       3/74
XIA  D  WE CALCULATE ABOVE XI(0) AND DXI(0)/DL+ FOR THEIR L+=.025+-.017 .         3/74
XIA  N  ARNOLD 74 FIG. 4 WAS USED TO OBTAIN XIA AND DXI/DL.                      11/75
XIA  M  MERLAN 74 FIG.5 WAS USED TO OBTAIN DXI/DL.                                3/74
XIA        . . . . . . . . . .
XIA FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS ABOVE.

XIB     XIB = F-/F+ (DETERMINED FROM KMU3/KE3)    ---------------------------
XIB      THE KMU3/KE3 BRANCHING RATIO FIXES A RELATIONSHIP BETWEEN XI(0)          1/74
XIB      AND L+.  WE QUOTE THE AUTHORS XI(0) AND ASSOCIATED L+ BUT DO NOT         1/74
XIB      AVERAGE BECAUSE THE L+ VALUES DIFFER.  THE FIT RESULT AND SCALE          1/74
XIB      FACTOR GIVEN IN THE ABOVE NOTE ON KL3 FORM FACTORS ARE NOT OBTAINED      2/76
XIB      FROM THESE XIB VALUES.  INSTEAD THEY ARE OBTAINED DIRECTLY FROM THE      2/76
XIB      FITTED KMU3/KE3 RATIO (R29).                                             2/76
XIB            -0.17      0.75      0.99   SHAKLEE   64 XEBC +  BR, L+=0          1/74
XIB            +0.6       0.5              BISI 1    65 HBC  +  BR, L+=0          1/74
XIB      500   +0.8       0.6              CUTTS     65 OSPK +  BR, L+=0          1/74
XIB      636   +0.4       0.4              CALLAHA1  66 FRBC +  BR, L+=0          1/74
XIB      306   +0.75      0.50             AUERBACH  67 OSPK +  BR, L+=0          1/74
XIB B 5601  (-0.08)     (0.15)             BOTTERIL2 68 ASPK +  BR,L+=.023+-.008  1/74
XIB E 1398  (-0.60)     (0.20)             EICHTEN   68 HLBC +  BR, SEE NOTE E    1/74
XIB      986   +1.0       0.6              GARLAND   68 OSPK +  BR, L+=0          1/74
XIB            +0.91      0.82             ZELLER    69 ASPK +  BR, L+=.023       1/74
XIB  B         -0.35      0.22             BOTTERIL  70 OSPK +  BR,L+=.045+-.015  1/74
XIB  E1505     -0.81      0.27             HAIDT     71 HLBC +  BR,L+=.028,FIG.8  1/74
XIB   5825      0.0       0.15             CHIANG    72 OSPK +  BR,L+=.03,FIG.10  1/74
XIB  H 55K     -0.12      0.12             HEINTZE   77 CNTR +  BR,L+=.029        3/78
XIB  B  BOTTERIL 70 IS REEVALUATION OF BOTTERIL 2 68 WITH DIFFERENT L+.          1/74
XIB E   EICHTEN 68 HAS L+=.023+-.008, T=4, INDEP. OF L-. REPL. BY HAIDT 71.      1/74
XIB  H  CALCULATED BY US FROM LO AND L+ GIVEN BELOW.                             3/78
XIB        . . . . . . . . . .
XIB FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS ABOVE.

XIC     XIC = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)    ------------
XIC      THE MU POLARIZATION IS A MEASURE OF XI(T). NO ASSUMPTIONS ON L+-
XIC      NECESSARY, T (WEIGHTED BY SENSITIVITY TO XI0) SHOULD BE SPECIFIED.
XIC     IN L+,XI(0) PARAMETERIZATION THIS IS XI(0) FOR L+=0.  DXI/DL=XI*T.
XIC      FOR RAD. CORR. TO MUON POLARIZATION IN KMU3 SEE GINSBERG 71.
XIC T 2100  (+1.2)     (2.4)     (1.8)   BORREANI  65 HLBC +  POLARIZATION        8/67
XIC T  500 BTWN -4.0 AND +1.7            CUTTS     65 OSPK +  LONG. POL.          1/74
XIC T  397  (-1.4)     (1.8)             CALLAHA1  66 FRBC +  TOTAL POL.          8/67
XIC T 2950  (-0.7)     (0.9)     (3.3)   CALLAHA1  66 FRBC +  LONG. POL.          8/67
XIC  B6000   -1.0       0.3              BETTELS   68 HLBC +  TOTAL POL. T=4.9    1/74
XIC  C3133   -0.95      0.3              CUTTS     69 OSPK +  TOTAL POL. T=4.0    1/74
XIC M  40K  (-0.64)    (0.27)            MERLAN    74 ASPK +  POL,DXI/DL=+1.7     3/74
XIC  D1585   -0.25      1.20             BRAUN     75 HLBC +  POL. T=4.2          1/76
XIC T   T VALUE NOT GIVEN.
XIC  B  BETTELS 68 DXI/DL=XI*T=-1.0*4.9=-4.9 .
XIC  C  CUTTS 69 T=4.0 WAS CALCULATED FROM FIG.8. DXI/DL=XI*T=-.95*4=-3.8 .     1/74
XIC M   MERLAN 74 POLARIZATION RESULT (FIG.5) NOT POSSIBLE.  SEE DISCUSSION      1/76
XIC M   OF POLARIZATION EXPERIMENTS IN NOTE ON KL3 FORM FACTORS ABOVE.           1/76
XIC  D  BRAUN 75 DXI/DL=XI*T=-.25*4.2=-1.0 .                                     1/76
XIC        . . . . . . . . . .
XIC FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS ABOVE.

IXI         IMAGINARY PART OF XI (TEST OF T REVERSAL)    ------------------
IXI   2648    0.0       1.0              CALLAHA1  66 FRBC +  MU                  1/74
IXI    397   +1.6       1.3              CALLAHA1  66 FRBC +  TOTAL POL.          1/74
IXI   2950    0.5       1.4       0.5    CALLAHA1  66 FRBC +  LONG. POL.          1/74
IXI   6000   -0.1       0.3              BETTELS   68 HLBC +  TOTAL POL.          1/74
IXI   3133   -0.3       0.3       0.4    CUTTS     69 OSPK +  TOTAL POL. FIG.7    1/74
IXI        . . . . . . . . . .
IXI AVG      -0.09      0.21    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
IXI STUDENT  -0.10      0.23    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

L+M     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KMU3 DECAY)   ---------
L+M      SEE ALSO THE CORRESPONDING ENTRIES AND FOOTNOTES IN SECTIONS XIA,
L+M      XIC, AND LO.
L+M      FOR RAD.COR. OF KMU3 DP SEE GINSBURG 70 AND BECHERRAWY 70.               3/74
L+M    444    0.0       0.05             CALLAHA1  66 FRBC +  PI                  1/74
L+M   2041    0.009     0.026            KIJEWSKI  69 OSPK +  PI                  1/74
L+M   3240    0.050     0.018            HAIDT     71 HLBC +  DP                  1/74
L+M  A4025    0.024     0.019            ANKENBRAN 72 ASPK +  PI                  1/74
L+M   3480   -0.006     0.015            CHIANG    72 OSPK +  DP                  1/74
L+M   1897    0.025     0.017            BRAUN1    73 HLBC +  DP                  3/74
L+M    490    0.025     0.030            ARNOLD    74 HLBC +  DP                  7/74
L+M   6527    0.027     0.019            MERLAN    74 ASPK +  DP                  3/74
L+M  A  ANKENBRANDT 72 L+ FROM FIG.3 TO MATCH DXI/DL. TEXT GIVES .024+-.022      1/74
L+M        . . . . . . . . . .
L+M FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS ABOVE.
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LO      LAMBDA 0 (LINEAR ENERGY DEPENDENCE OF F0 IN KMU3 DECAY)   ----------
LO       WHEREVER POSSIBLE, WE HAVE CONVERTED THE ABOVE VALUES OF XI(0) INTO
LO       VALUES OF LO USING THE ASSOCIATED L+M AND DXI/DL.
LO W   444   +0.058    0.036             CALLAHA1  66 FRBC +  PI,DLO/DL+=-0.37   1/74
LO L  6000   -0.063   (0.024)            BETTELS   68 HLBC +  POL,DLO/DL+=+.60   1/74
LO L  3133   -0.056   (0.024)            CUTTS     69 OSPK +  PCL,DLO/DL+=+.69   1/74
LO W  2041   -0.031    0.045             KIJEWSKI  69 OSPK +  PI,DLO/DL+=-1.10   1/74
LO W  3240   -0.039    0.029             HAIDT     71 HLBC +  DP,DLO/DL+=-1.34   1/74
LO W  4025   -0.026    0.013             ANKENBRAN 72 ASPK +  PI,DLO/DL+=+0.03   1/74
LO W  3480   +0.030    0.014             CHIANG    72 OSPK +  DP,DLO/DL+=-0.21   1/74
LO    D1897  -0.008    0.020             BRAUN1    73 HLBC +  DP,DLO/DL+=-0.53   1/76
LO      490  -0.040    0.040             ARNOLD    74 HLBC +  DP,DLO/DL+=-0.62   7/74
LO  B       (-0.017)  (0.011)            BRAUN     74 HLBC +  KMU3/KE3 VS. T    11/75
LO M  6527   -0.019    0.015             MERLAN    74 ASPK +  DP,DLO/DL+=+0.27   3/74
LO L  1585   +0.008    0.097             BRAUN     75 HLBC +  POL,DLO/DL+=+.92   1/76
LO     H 55K +0.019   (0.010)            HEINTZE   77 SPEC +  BR,DLO/DL+=+0.03 12/77
LO W     LO CALCULATED BY US FROM XI0, L+M, AND DXI/DL.                           1/74
LO L     LO VALUE IS FOR L+=0.03  CALCULATED BY US FROM XI0 AND DXI/DL.           1/74
LO   D   THIS VALUE AND ERROR ARE TAKEN FROM BRAUN 75 BUT CORRESPOND TC THE       1/76
LO   D   BRAUN1 73 L+M RESULT.  DLO/DL+ IS FROM BRAUN1 73 DXI/DL IN XIA ABV.      1/76
LO  B    BRAUN 74 IS A COMBINED KMU3-KE3 RESULT.  IT IS NOT INDEPENDENT OF       11/75
LO  B    BRAUN1 73 (KMU3) AND BRAUN2 73 (KE3) FORM FACTOR RESULTS.               11/75
LO M     MERLAN 74 LO AND DLO/DL+ WERE CALCULATED BY US FROM XIA, L+M, AND        3/74
LO M     DXI/DL.  THEIR FIG.6 GIVES LO=-0.025+-0.012 AND NO DLO/DL+.              3/74
LO   H   HEINTZE 77 USES L+=0.029+-0.003.  DLO/DL+ ESTIMATED BY US.              12/77
LO         . . . . . . . . . .
LO  FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS ABOVE.

L+E      LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KE3 DECAY)   ---------
L+E      FOR RAD.COR. OF KE3 DP SEE GINSBURG 67 AND BECHERRAWY 70.                3/74
L+E    217   +0.036     .045             BROWN     62 XEBC +  PI, NO RC
L+E    407   -0.010     .029             JENSEN    64 XEBC +  PI, NO RC           8/67
L+E    230   -0.04      .05              BORREANI  64 HBC  +  E+, NO RC           8/67
L+E    854    0.045    0.017     0.018   BELLOTT2  67 FBC  +  DP, USES RC        11/67
L+E   1393   +0.016     .016             IMLAY     67 OSPK +  DP, NO RC           8/67
L+E    515   +0.028     .013      .014   KALMUS    67 FBC  +  E+, PI, NO RC       8/67
L+E    960     .08      .04              BOTTERIL1 68 ASPK +  E+, USES RC       . 6/68
L+E     90   -0.02     0.08      0.12    EISLER    68 HLBC +  PI, USES RC         6/68
L+E   1458    .045      .015             BOTTERIL  70 OSPK    PI, USES RC        10/69
L+E   2707    C.027    0.010             STEINER   71 HLBC +  DP, USES RC        11/71
L+E   4017    0.029    0.011             CHIANG    72 OSPK +  DP, RC NEGLIGBLE    9/72
L+E  A        0.027    0.008             BRAUN2    73 HLBC +  DP, NO RC           3/74
L+E B        (0.025)  (0.007)            BRAUN     74 HLBC +  KMU3/KE3 VS. T     11/75
L+E  A   BRAUN2 73 STATES THAT RC OF GINSBERG 67 WOULD LOWER L+E BY .002 BUT      3/74
L+E  A   THAT RC OF BECHERRAWY DISAGREES AND WOULD RAISE L+E BY .005 .            1/76
L+E B    BRAUN 74 IS A COMBINED KMU3-KE3 RESULT.  IT IS NOT INDEPENDENT OF       11/75
L+E B    BRAUN1 73 (KMU3) AND BRAUN2 73 (KE3) FORM FACTOR RESULTS.               11/75
L+E        . . . . . . . . . .
L+E AVG       0.0285   0.0043   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
L+E STUDENT   0.0284   0.0047   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

FS      FS/F+  RATIO OF SCALAR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FS              .18   OR LESS  CL=.90    BELLOTT2  67 HLBC                       10/69
FS              .30   OR LESS  CL=.95    KALMUS    67 HLBC +                     10/69
FS             0.23   OR LESS  CL=.90    BOTTERIL1 68 ASPK                        8/66
FS    2707     0.14      0.03      0.04  STEINER   71 HLBC +  L+,FS,FT,PHI FIT   2/72
FS    4017     0.13   OR LESS  CL=.90    CHIANG    72 OSPK +                      9/72
FS    2827     0.00      0.10            BRAUN     75 HLBC +                     12/75
FS         . . . . . . . . . .
FS  AVG        0.125     0.044    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
FS  STUDENT    0.126     0.037    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

FT      FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FT              .58   OR LESS  CL=.90    BELLOTT2  67 HLBC                       10/69
FT             1.1    OR LESS  CL=.95    KALMUS    67 HLBC +                     10/69
FT             0.58   OR LESS  CL=.90    BOTTERIL1 68 ASPK                        8/66
FT    2707     0.24      0.16      0.14  STEINER   71 HLBC +  L+,FS,FT,PHI FIT   2/72
FT    4017     0.75   OR LESS  CL=.90    CHIANG    72 OSPK +                      9/72
FT    2827     0.07      0.37            BRAUN     75 HLBC +                     12/75
FT         . . . . . . . . . .
FT  AVG        0.22      0.14     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
FT  STUDENT    0.22      0.15     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

FTM     FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KMU3 DECAY    ------------
FTM   1585     0.02      0.12            BRAUN     75 HLBC                        1/76

KE4     KE4 DECAY FCRM FACTORS ARE GIVEN IN THE FOLLOWING PAPERS
KE4                                      BASILE    71 ASPK +                     11/75
KE4                                      BEIER     73 OSPK +-                    11/75
KE4                                      ROSSELET  77 SPEC +                      2/80*

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REFERENCES FOR CHARGED K


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BIRGE     56 NC    4   834      BIRGE,PERKINS,PETERSON,STORK,WHITEHEA (LRL)
ILOFF     56 PR 102    927      ILOFF,GOLDHABER,LANNUTTI,GILBERT +    (LRL)
ALEXANDE  57 NC    6   478      ALEXANDER,JOHNSTON,OCEALLAIGH (DUBLIN INST)
COHEN     57 FUND.CCNS.PHYS.    +CROWE,DUMOND        (ATOMICS INTER.+LRL+CIT)
EISENBER  58 NC    8   663      EISENBERG,KOCH,LOHRMANN,NIKOLIC +    (BERN)
BURROWES  59 PRL   2   117      BURROWES,CALDWELL,FRISCH,HILL +       (MIT)
TAYLOR    59 PR 114    359      S TAYLOR,HARRIS,OREAR,LEE,BAUMEL (COLUMBIA)

FREDEN    60 PR 118    564      S C FREDEN,F C GILBERT,R S WHITE      (LRL)
BARKAS    61 PR 124 1209        BARKAS,DYER,MASON,NORRIS,NICKOLS,SMIT (LRL)
BHOWMIK   61 NC   20   857      B BHOWMIK,P C JAIN,P C MATHUR (DELHI UNIV)
FERRO-LU  61 NC    22  1087     FERRO-LUZZI,MILLER,MURRAY,ROSENFELD+  (LRL)
NORDIN    61 PR 123 2166        PAUL NORDIN JR                        (LRL)
ROE       61 PRL   7   346      ROE,SINCLAIR,BROWN,GLASER +       (MICH+LRL)
BOYARSKI  62 PR 128 2398        BOYARSKI,LOH,NIEMELA,RITSON           (MIT)
BROWN     62 PRL   8   450      BROWN,KADYK,TRILLING,ROE+        (LRL,MICH)
BARKAS    63 PRL  11    26      W H BARKAS,J N DYER,H H HECKMAN       (LRL)

BORREANI  64 PL     12 123      G BORREANI,G RINAUDO,A WERBROUCK   (TURIN)
CALLAHAN  64 PR   136 B 1463    A CALLAHAN,R MARCH,R STARK      (WISCONSIN)
CAMERINI  64 PRL   13 318       CAMERINI,CLINE,FRY,POWELL   (WISCONSIN+LRL)
CLINE     64 PRL   13 101       D CLINE, W F FRY                (WISCONSIN)
GIACOMEL  64 NC 34   1134       GIACOMELLI,MONTI,QUARENI+ (BOLOGNA,MUNICH)
GREINER   64 PRL   13 284       D GREINER, W OSBORNE, W BARKAS        (LRL)
JENSEN    64 PR   136 B1431     JENSEN,SHAKLEE,ROE,SINCLAIR          (MICH)
KALMUS    64 PRL    13    99    +KERNAN,PU,POWELL,DOWD           (LRL,WISC)
SHAKLEE   64 PR   136 B 1423    SHAKLEE,JENSEN,ROE,SINCLAIR          (MICH)

BIRGE     65 PR 139 B 1600      BIRGE,ELY,GIDAL,CAMERINI,CLINE + (LRL+WISC)
BISI      65 NC    35  768      BISI,BORREANI,CESTER,FERRARO +     (TORINO)
BISI 1    65 PR 139 B 1068      BORREANI,MARZARI-CHIESA,RINAUDO+   (TORINO)
BORREANI  65 PR 140 B1686       BORREANI,GIDAL,RINAUDO,CAFORIO+ (BARI,TORI)
CALLAHAN  65 PRL   15  129      A CALLAHAN,D CLINE              (WISCONSIN)
CAMERINI  65 NC 37 1795         +CLINE,GIDAL,KALMUS,KERNAN       (WISC+LRL)
CLINE     65 PL    15  293      A CLINE,W F FRY                 (WISCONSIN)
CUTTS     65 PR 138 B969        CUTTS,ELIOFF,STIENING                 (LRL)

DE MARCO  65 PR 140 B 1430      DE MARCO,GROSSO,RINAUDO       (TORINO+CERN)
FITCH     65 PR 140 B 1088      FITCH,QUARLES,WILKINS(PRINCETON+MT HOLYOKE)
GREINER   65 ARNS  15   67      QUOTED BY BARKAS                      (LRL)
STAMER    65 PR  138 B 440      STAMER,HUETTER,KOLLER,TAYLOR,GRAUMAN (STEV)
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Stable Particles

$K^{\pm}$, K^0

Data Card Listings

For notation, see key at front of Listings.


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TRILLING 65 UCRL 16473          GEORGE H TRILLING                       (LRL)
   UPDATED FROM 1965 ARGONNE CONF., PAGE 5.
YOUNG    65 UCRL 16362          POH-SHIEN YOUNG (THESIS,BERKELEY)       (LRL)
   ALSO 67 PR 156 1464          P-S YOUNG,W.Z.OSBORNE,W.H.BARKAS        (LRL)

CALLAHA1 66 PR 150 1153         CALLAHAN,CAMERINI+(WISC,LRL,RIVERSIDE,BARI)
CALLAHAN 66 NC  44A 90          A C CALLAHAN                      (WISCONSIN)
CESTER   66 PL 21 343           CESTER,ESCHSTRUTH,ONEILL+   (PRINCETON-PENN)
   ALSO 67 AUERBACH, FOOTNOTE 1.

AUERBACH 67 PR 155  1505        +DOBBS,MANN,MCFARLANE,WHITE+     (PENN,PRIN)
   ALSO 74 PR D9 3216           ERRATUM
BELLOTT1 67 HEIDELBERG CONF     BELLOTTI,PULLIA                         (MILAN)
BELLOTT2 67 NC 52A  1287        BELLOTTI,FIORINI,PULLIA                 (MILAN)
   ALSO 66 PL  20  690          BELLOTTI,FIORINI,PULLIA+                (MILAN)
BISI     67 PL 25B  572         BISI,CESTER,CHIESA,VIGONE              (TORINO)

BOTTERIL 67 PRL  19  982        BOTTERILL,BROWN,CORBETT,CULLIGAN + (OXFORD)
   ALSO 68 BOTTERIL
BOWEN    67 PR 154 1314         BOWEN,MANN,MCFARLANE,HUGHES+(PENN-PRINCETO)
CLINE1   67 HEIDELBERG CONF     CLINE,HAGGERTY,SINGLETON,FRY+   (WISCONSIN)
CLINE2   67 HERCEG NOVI TBL.4 D.CLINE,PROC.INTL.SCH.ON ELEM.PART.PHYSICS

FLETCHER 67 PRL  19  98         FLETCHER,BEIER,EDWRADS,+             (ILLINCIS)
FORD     67 PRL 18 1214         +LEMONICK,NAUENBERG,PIROUE          (PRINCETON)
IMLAY    67 PR 160  1203        IMLAY,ESCHSTRUTH,FRANKLIN+          (PRINCETON)
KALMUS   67 PR  159  1187       KALMUS,KERNAN                            (LRL)
ZINCHENK 67 RUTGERS(THESIS)     ZINCHENKO                            (RUTGERS)

BETTELS  68 NC 56A 1106         AACHEN-BARI-BERGEN-CERN-EP-NIJMEGEN-ORSAY+
   ALSO 71 HAIDT
BOTTERIL 68 PR 171 1402         BOTTERILL,BROWN,CLEGG,CORBETT +      (OXFORD)
BOTTERI1 68 PR 174 1661         BOTTERILL,BRCWN,CLEGG,CORBETT +      (OXFCRD)
BOTTERI2 68 PRL 21 766          BOTTERILL,BROWN,CLEGG,CORBETT +      (OXFORD)
BUTLER   68 UCRL-18420          +BLAND,GOLDHABER,GOLDHABER,HIRATA+      (LRL)
CHANG    68 PRL 20  510         CHANG,YODH,EHRLICH,PLANO+(MARYLAND,RUTGERS)

CHEN     68 PRL 20 73           CHEN,CUTTS,KIJEWSKI,STIENING +      (LRL,MIT)
EICHTEN  68 PL 27B 586          AACHEN-BARI-CERN-EP-ORSAY-PADOVA-VALENCIA
EISLER   68 PR  169  1090       EISLER,FUNG,MARATECK,MEYER,PLANO  (RUTGERS)
ESCHSTRU 68 PR  165  1487       ESCHSTRUTH,FRANKLIN,HUGHES+(PRINCETON,PENN)
GARLAND  68 PR  167  1225       +TSIPIS,DEVONS,ROSEN+   (COLUMBIA,RUTG,WISC)
MOSCOSO  68  THESIS             M L MOSCOSO               (UNIV PARIS ORSAY)

CUTTS    69 PR 184 1380         +STIENING,WIEGAND,DEUTSCH           (LRL,MIT)
   ALSO 68 PRL 20 955           CUTTS,STIENING,WIEGAND,DEUTSCH      (LRL,MIT)
DAVISON  69 PR  180 1333        +BACASTOW,BARKAS,EVANS,FUNG,PORTER+    (UCR)
ELY      69 PR  180 1319        ELY,GIDAL,HAGOPIAN,KALMUS+  (LOUC+WISC+LRL)
EMMERSON 69 PRL 23 393          EMMERSON,QUIRK                       (OXFORD)

HERZO    69 PR 186 1403         +BANNER,BEIER,BERTRAM,EDWARDS +          (ILL)
KIJEWSKI 69 UCRL-18433 THESIS P K KIJEWSKI                            (LBL)
LOBKOWIC 69 PR 185 1676         +MELISSINOS,NAGASHIMA,TEWKSBURY+ (ROCH,BNL)
   ALSO 66 PRL 17 548           LOBKOWICZ,MELISSINOS,NAGASHIM+   (ROCH+BNL)
MACEK    69 PRL  22   32        MACEK,MANN,MC FARLANE,ROBERTS+(PENN,TEMPLE)
MAST     69 PR  183 1200        +GERSHWIN,ALSTON-GARNJOST,BANGERTER+  (LRL)
ZELLER   69 PR  182 1420        ZELLER,HADDOCK,HELLAND,PAHL+      (UCLA,LRL)

BOTTERIL 70 PL 31B 325          +BROWN,CLEGG,CORBETT,CULLIGAN+          (CXF)
FORD     70 PRL 25 1370         +PIROUE,REMMEL,SMITH,SOUDER             (PRIN)
GRAUMAN  70 PR D1 1277          +KOLLER,TAYLOR,PANDOULAS+  (STEV,SETO,LEHI)
   ALSO 69 PRL 23 737           +KOLLER,TAYLOR,PANDOULAS+  (STEV,SETO,LEHI)
MACEK    70 PR D1 1249          +MANN,MCFARLANE,ROBERTS                 (PENN)
MALTSEV  70 SJNP 10 678         +PESTOVA,SOLODOVNIKOVA,FADEEV +         (JINR)
PANDOULA 70 PR D2 1205          +TAYLOR,KOLLER,GRAUMAN +           (STEV,SETO)

BASILE   71 PL 36B 619          +BREHIN,DIAMANT-BERGER,KUNZ+      (SACL+GEVA)
BOURQUIN 71 PL 36B 615          +BOYMOND,EXTERMANN,MARASCO+       (GEVA,SACL)
HAIDT    71 PR D3 10            AACHEN+BARI+CERN+EP+NIJMEGEN+ORSAY+PADOVA+
   ALSO 69 PL  29B 691          +(AACH,BARI,CERN,EPOL,NIJM,ORSAY,PADO,TORI)
KLEMS    71 PR D4 66            +HILDEBRAND,STIENING                (CHIC,LRL)
   ALSO 70 PRL 24 1086          KLEMS,HILDEBRAND,STIENING           (LRL,CHIC)
   ALSO 70 PRL 25 473           KLEMS,HILDEBRAND,STIENING           (LRL,CHIC)

KUNSELMA 71 PL 34B 485          R. KUNSELMAN                         (WYOMING)
OTT      71 PR D3 52            OTT,PRITCHARD                           (LOQM)
ROMANO   71 PL 36B 525          +RENTON,AUBERT,BURBAN-LUTZ (BARI,CERN,ORSA)
SCHWEINB 71 PL 36B 246          AACHEN+BELGIUM+CERN+NIJMEGEN+PADOVA COLLAB
STEINER  71 PL 36B 521          AACHEN+BARI+CERN+EPOL+ORSA+NIJM+PADO+TORIN

ABRAMS   72 PRL 29 1118         +CARROLL,KYCIA,LI,MENES,MICHAEL +        (BNL)
ANKENBRA 72 PRL 28 1472         ANKENBRANDT,LARSEN+     (BNL+LASL+FNAL+YALE)
AUBERT   72 NC 12A 509          +HEUSSE,PASCAUD,VIALLE+     (ORSA+BRUX+EPOL)
BEIER    72 PRL 29 678          +BUCHHOLZ,MANN,PARKER           (PENNSYLVANIA)
CHIANG   72 PR D6 1254          +ROSEN,SHAPIRO,HANDLER,OLSEN+     (ROCH+WISC)

CLARK    72 PRL 29 1274         +CORK,ELIOFF,KERTH,MCREYNOLDS,NEWTON+ (LBL)
EDWARDS  72 PR D5 2720          +BEIER,BERTRAM,HERZO,KOESTER +           (ILL)
FORD     72 PL 38B 335          +PIROUE,REMMEL,SMITH,SOUDER        (PRINCETON)
HOFFMAST 72 NP B36 1            HOFFMASTER,KOLLER,TAYLOR+   (STEV+SETO+LEHI)

ABRAMS   73 PRL 30 500          +CARROLL,KYCIA,LI,MENES,MICHAEL +        (BNL)
BACKENST 73 PL 43B 431          BACKENSTOSS,BAMBERGER+(CERN+KARL+HEID+STOH)
BEIER    73 PRL 30 399          +BUCHHOLZ,MANN,PARKER,ROBERTS           (PENN)
BRAUN1   73 PL 47B 182          AACHEN+BARI+BRUSSELS+CERN COLLABORATION
   ALSO 75 BRAUN
BRAUN2   73 PL 47B 185          AACHEN+BARI+BRUSSELS+CERN COLLABORATION
   ALSO 75 BRAUN
CABLE    73 PR D8 3807          +HILDEBRAND,PANG,STIENING            (EFI+LBL)

LJUNG    73 PR D8 1307          D.LJUNG,D.CLINE                         (WISC)
   ALSO 72 PRL 28 523           D.LJUNG                                 (WISC)
   ALSC 72 PRL 28 1287          D.CLINE,D.LJUNG                         (WISC)
   ALSO 69 PRL 23 326           CAMERINI,LJUNG,SHEAFF,CLINE             (WISC)
LUCAS1   73 PR D8 719           LUCAS,TAFT,WILLIS                       (YALE)
LUCAS2   73 PR D8 727           LUCAS,TAFT,WILLIS                       (YALE)
PANG     73 PR D8 1989          +HILDEBRAND,CABLE,STIENING   (EFI+ARIZ+LBL)
   ALSO 72 PL 40B 699           CABLE,HILDEBRAND,PANG,STIENING       (EFI+LBL)
SMITH    73 NP B60 411          +BOOTH,RENSHALL,JONES+ (GLAS+LIVP+OXF+RHEL)

ARNOLD   74 PR D9 1221          C L ARNOLD,B P ROE,D SINCLAIR           (MICH)
BRAUN    74 PL 51B 393          +CORNELSSEN,MARTYN +   (AACH+BARI+BRUX+CERN)
CENCE    74 PR D10 776          +HARRIS,JONES,MORGADO +       (HAWA+LBL+WISC)
   ALSO 73 THESIS (UNPUBL.)     D B CLARKE                              (WISC)
KUNSELMA 74 PR C9 2469          R.KUNSELMAN                             (WYOM)
MERLAN   74 PR D9 107           +KASHA,WANDERER,ADAIR+        (YALE+BNL+LASL)
WEISSENB 74 PL 48B 474          WEISSENBERG,EGOROV,MINERVINA +   (ITEP+LEBD)

BLOCH    75 PL 56B 201          +BREHIN,BUNCE,DEVAUX+              (SACL+GEVA)
BRAUN    75 NP B89 210          +CORNELSSEN,MARTYN+    (AACH+BARI+BRUX+CERN)
CHENG    75 NP A254 381         +ASANO,CHEN,DUGAN,HU,WU,HUGHES+ (COLU+YALE)
HEARD1   75 PL 55B 324          +HEINTZE,HEINZELMANN+              (CERN+HEID)
HEARD2   75 PL 55B 327          +HEINTZE,HEINZELMANN+              (CERN+HEID)
SHEAFF   75 PR D12 2570         M. SHEAFF                               (WISC)
SMITH    75 NP B91 45           +BOOTH,RENSHALL,JONES+ (GLAS+LIVP+OXF+RHEL)

BERTRAND 76 NP B114 387         +SACTON +          (BRUX+UBEL+DUUC+LOUC+WARS)
BLOCH    76 PL 60B 393          +BUNCE,DEVAUX,DIAMANT-BERGER+     (GEVA+SACL)
BRAUN    76 LNC 17 521          +MARTYN,ERRIQUEZ +      (AACH+BARI+BELG+CERN)
DIAMANTB 76 PL 62B 485          DIAMANT-BERGER,BLOCH,DEVAUX +     (SACL+GEVA)
HEINTZE  76 PL 60B 302          +HEINZELMANN,IGO-KEMENES,MUNDHENKE+    (HEID)
SMITH    76 NP B109 173         +BOOTH,RENSHALL,JONES+ (GLAS+LIVP+OXF+RHEL)
WEISSENB 76 NP B115 55          WEISSENBERG,EGOROV,MINERVINA+     (ITEP+LEBD)

ABRAMS   77 PR D15 22           +CARROLL,KYCIA,LI,MICHAEL,MOCKETT +     (BNL)
DEVAUX   77 NP B126 11          +BLOCH,DIAMANT-BERGER,MAILLARD+ (SACL+GEVA)
HEINTZE  77 PL 70B 482          +HEINZELMANN,IGO-KEMENES,+         (HEID+CERN)
ROSSELET 77 PR D15 574          +EXTERMANN,FISCHER,GUISAN +        (GEVA+SACL)
BARKOV   79 NP B148 53          +VASSERMAN,ZOLOTOREV,KRUPIN+ (SIBERIA+KIAE)
HEINTZE  79 NP B149 365         +HEINZELMANN,IGO-KEMENES+          (HEID+CERN)

        QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

BLOCK    62 CERN CONF 371       BLOCK,LENDINARA,MONARI         (NWES+BOLOGNA)

                                PAPERS NOT REFERRED TO IN DATA CARDS

BRENE    61 NP 22 553           BRENE,EGARDT,QVIST                      (NORD)
BIRGE    63 PRL  11  35         BIRGE,ELY,GIDAL,CAMERINI +  (LRL+WISC+BARI)
ADAIR    64 PL 12  67           ADAIR,LEIPUNER                      (YALE,BNL)
CABIBBO  64 PL   9 352          CABIBBO,MAKSYMOWICZ                     (CERN)
   ALSO 64 PL 11 360            CABIBBO,MAKSYMOWICZ                     (CERN)
   ALSO 65 PL 14  72            CABIBBO,MAKSYMOWICZ                     (CERN)

CABIBBO  66 BERKELEY CONF 33    CABIBBO                                 (CERN)
GINSBERG 67 PR 162  1570        EDWARD S GINSBERG            (U. MASS BOSTON)
WILLIS   67 HEIDELBERG 273      W J WILLIS -RAPPORTEUR TALK             (YALE)
CRONIN   68 VIENNA CONF 241     RAPPORTEUR TALK                    (PRINCETON)
HAIDT 2  69 PL 29B 696          + (AACH,BARI,CERN,EPOL,NIJM,ORSA,PADO,TCRI)

BARDIN   70 PL 32B 121          BARDIN,BILENKY,PONTECORVO               (JINR)
BECHERRA 70 PR D1 1452          T.BECHERRAWY                            (ROCH)
FEARING  70 PR D3 542           +FISCHBACK,SMITH                   (STON+BOHR)
GAILLARD 70 CERN 70-14          M K GAILLARD, L M CHOUNET          (CERN+ORSA)
GINSBERG 70 PR D1 229           E S GINSBERG                       (IIT HAIFA)

GINSBERG 71 PR D4 2893          E S GINSBERG                             (MIT)
CHOUNET  72 PL 4C 199           (PHYS. REPTS.)CHOUNET,2*GAILLARD(ORSA+CERN)
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K^0

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              11   NEUTRAL K(498,JP=0-) I=1/2

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              11   NEUTRAL K MASS (MEV)

M              498.1      0.4            CHRISTENS 64 OSPK
M       2223   497.44     0.33           KIM       65 HBC    KO FROM PBAR P    6/66
M       4500   498.9      0.5            BALTAY    66 HBC    KO FROM PBAR P    6/66
M              497.44     0.50           FITCH     67 OSPK                    11/67
M              . . . . . . . . .
M    AVG       497.87     0.32    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
M    STUDENT   497.83     0.26    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M    FIT       497.67     0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  2/80*
                          (SEE IDEOGRAM BELOW )
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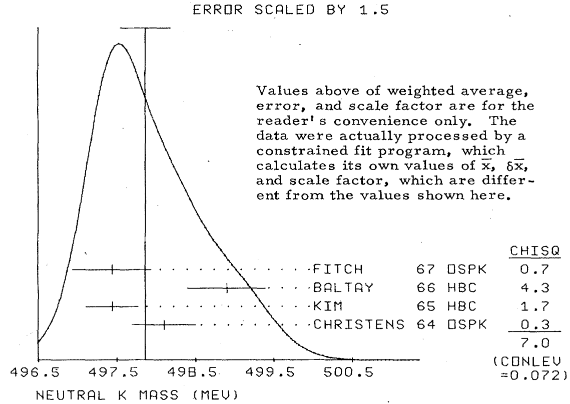
WEIGHTED AVERAGE = 497.87 ± 0.32
ERROR SCALED BY 1.5

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              11   (KO) - (K+-) MASS DIFFERENCE (MEV)

D               3.9       0.6            ROSENFELD 59 HBC   -
D               5.4       1.1            CRAWFORD  59 HBC   +
D          9    3.90      0.25           BURNSTEIN 65 HBC   -
D          7    3.71      0.35           KIM       65 HBC   -   K- P TO KO N       6/68
D        417    3.95      0.21           HILL      68 DBC   +   K+D TO KOPP        3/68
D              . . . . . . . . .
D    AVG        3.92      0.14    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D    STUDENT    3.91      0.15    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
D    FIT        4.01      0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  2/80*

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REFERENCES FOR NEUTRAL K


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CRAWFORD 59 PRL   2  112        CRAWFORD,CRESTI,GOOD,STEVENSON,TICHO  (LRL)
ROSENFEL 59 PRL   2  110        A H ROSENFELD,F SOLMITZ,R D TRIPP     (LRL)
CHRISTEN 64 PRL 13 138          CHRISTENSON,CRONIN,FITCH,TURLAY (PRINCETON)
BURNSTEI 65 PR  138 B 895       R A BURNSTEIN,H A RUBIN           (MARYLAND)
KIM      65 PR 140 B 1334       J K KIM,L KIRSCH,D MILLER         (COLUMBIA)
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

K^0, K^0_S

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BALTAY    66 PR 142    932       BALTAY,SANDWEISS,STONEHILL +      (YALE+BNL)
FITCH     67 PR 164   1711       FITCH,ROTH,RUSS,VERNON             (PRINCETON)
HILL      68 PR 168   1534       HILL,ROBINSCN,SAKITT,CANTER  (BNL,CARNEGIE)

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K^0_S

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              12   SHORT-LIVED NEUTRAL K(498, JP=0-) I=1/2

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              12   KOS MEAN LIFE (UNITS 10**-10 SEC)

T       KOS MEAN LIFE (PRE-1971 EXPERIMENTS)
T   O    90    (1.07)    (0.13)    (0.13) BOLDT      58 CC
T       512     0.94      0.05      0.05  CRAWFORD   59 HBC
T   O    63    (1.09)    (0.18)    (0.15) BOWEN      60 CC
T   C    OLD EXPTS WITH LOW STATISTICS NOT INCLUDED IN AVERAGE.                6/68
T       378     0.94      0.05      0.05  BERTANZA   62 HBC
T       503     0.87      0.05            CHRETIEN   63 HLBC
T       545     0.86      0.04            KREISLER   64 OSPK
T               0.866     0.016           ALFF-STEI  66 OSPK                   9/66
T       572     0.90      0.06      0.05  AUERBACH   66 OSPK                   8/67
T      4500     0.92      0.04            BALTAY     66 HBC                    6/66
T   B          (0.904)   (0.024)          BOTT-BODE  66 OSPK                   9/66
T      5000     0.843     0.013           KIRSCH     66 HBC                    6/66
T     19994     0.856     0.008           DONALD     68 HBC                    6/68
T   H 20000     0.872     0.009           HILL       68 DBC                   11/72
T           . . . . . . . . . .
T    AVG        0.8641    0.0065    0.0065 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.3)
T    STUDENT .  0.8642    0.0060    0.0059 AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT

T       KOS MEAN LIFE (POST-1971 EXPERIMENTS)
T        THESE VALUES ARE USED TO DETERMINE THE STABLE PARTICLE TABLE
T        VALUES OF THE KOS MEAN LIFE AND RATES.
T   H    50K    0.8958    0.0045           SKJEGGEST 72 HBC                    1/73
T    F 2173    (0.867)   (0.024)           FACKLER   73 OSPK                  11/73
T         6M    0.8937    0.0048           GEWENIGER 74 ASPK                   3/74
T   C           0.8913    0.0032           CARITHERS 75 SPEC                   7/75
T        26K    0.881     0.009            ARONSON   76 SPEC                  11/76
T           . . . . . . . . . .
T    AVG        0.8923    0.0022    0.0022 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T    STUDENT    0.8924    0.0025    0.0024 AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
T    FIT        0.8923    0.0022 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

                      COMMENTS
T   H    HILL 68 HAS BEEN CHANGED BY THE AUTHORS FROM THE PUBLISHED VALUE    11/72
T   H    (0.865+-0.009) BECAUSE OF A CORRECTION IN THE SHIFT DUE TO ETA+-.   11/72
T   H    SKJEGGESTAD 72 AND HILL 68 GIVE DETAILED DISCUSSIONS OF SYSTEMATICS
T   H    ENCOUNTERED IN THIS TYPE OF EXPERIMENT.
T    B   KOS MEAN LIFE NOT THE PRIMARY QUANTITY MEASURED IN THIS EXPT.        6/68
T    F   FACKLER 73 DOES NOT INCLUDE SYSTEMATIC ERRORS.                      11/73
T   C    CARITHERS 75 VALUE IS FOR KOL-KOS MASS DIFFERENCE DM=.5348+-.0021.  11/75
T   C    THE DM DEPENDENCE OF THE TOTAL DECAY RATE (INVERSE MEAN LIFE) IS    11/75
T   C    GAMMA(KOS)=((1.122+-.004)+.16*(DM-.5348)/DM)*10**10 /SEC.           11/75
T   C    VALUE WOULD NOT CHANGE WITH OUR CURRENT DM=.5349+-.0022.             2/76

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              12   KOS PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      KOS INTO PI+ PI-                                 139+ 139
P2      KOS INTO PIO PIO                                 134+ 134
P3      KOS INTO MU+ MU-                                 105+ 105
P4      KOS INTO E+ E-                                    .5+  .5
P5      KOS INTO PI+ PI- GAMMA                           139+ 139+    0
P6      KOS INTO GAMMA GAMMA                               0+    0
P7      KOS INTO 3PIO                                    134+ 134+ 134

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              12   KOS BRANCHING RATIOS

R1      KOS INTO (PI+ PI-)/TOTAL                        (P1)
R1              0.68      0.04            CRAWFORD  59 HBC
R1              0.70      0.08            COLUMBIA  60 HBC
R1  U          (0.740)   (0.024)          ANDERSON  62 HBC
R1 U  3447      0.670     0.010           DOYLE     69 HBC      PI- P TO LAM KO   1/76
R1  U   ANDERSON RESULT NOT PUBLISHED, EVENTS ADDED TO DOYLE SAMPLE               2/71
R1          . . . . . . . . . .
R1  AVG         0.6710    0.0096   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT     0.671     0.010    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT         0.6861    0.0024 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R2      KOS INTO (PIO PIO)/TOTAL                        (P2)
R2              0.27      0.11            CRAWFORD  59 HBC
R2              0.26      0.06            BAGLIN    60 HLBC
R2              0.30      0.035           BROWN     61 HLBC
R2     1066     0.335     0.014           BROWN     63 HLBC
R2      198     0.288     0.021           CHRETIEN  63 HLBC
R2          . . . . . . . . . .
R2  AVG         0.316     0.014    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R2  STUDENT     0.316     0.014    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2  FIT         0.3139    0.0024 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                         (SEE IDEOGRAM BELOW )

R3      KOS INTO (PI+ PI-)/(PIO PIO)                    (P1)/(P2)
R3  N   267    (2.12)    (0.17)           BOZOKI    69 HLBC                        5/70
R3  G 3016     (2.285)   (0.055)          GOBBI     69 OSPK    K+N TO KOP          5/69
R3    3700      2.10      0.06            MORFIN    69 HLBC    K+N TO KOP         10/69
R3 G  7944      2.282     0.043           MOFFETT   70 OSPK    K+N TO KOP          2/72
R3 B  6150      2.22      0.095           BALTAY    71 HBC   K-P TO KO +NEUTRALS 12/71
R3 A  3068      2.22      0.10            ALITTI    72 HBC     K+P TO PI+ P KO     6/72
R3    6380      2.22      0.08            MORSE     72 DBC     K+N TO KOP          2/72
R3 N   701      2.10      0.11            NAGY      72 HLBC    K+N TO KOP          1/73
R3    4799      2.16      0.08            HILL      73 DBC     K+D TO KO P P       9/73
R3     16K      2.169     0.094           COWELL    74 OSPK    PI- P TO LAM KO     7/75
R3    1315      2.11      0.09            EVERHART  76 WIRE    PI- P TO LAM KO    11/76
R3 N    NAGY 72 IS A FINAL RESULT WHICH INCLUDES BOZOKI 69.                       11/73
R3 G    MOFFETT 70 IS A FINAL RESULT WHICH INCLUDES GOBBI 69.                      2/72
R3 B    THE DIRECTLY MEASURED QUANTITY IS KS TO PI+PI-/ALL KOBAR=.345+-.005 12/71
R3 A    THE DIRECTLY MEASURED QUANTITY IS KOS TO PI+ PI-/ALL KO=.345+-.005   6/72
R3          . . . . . . . . . .
R3  AVG         2.197     0.026    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  STUDENT     2.192     0.031    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3  FIT         2.186     0.025  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
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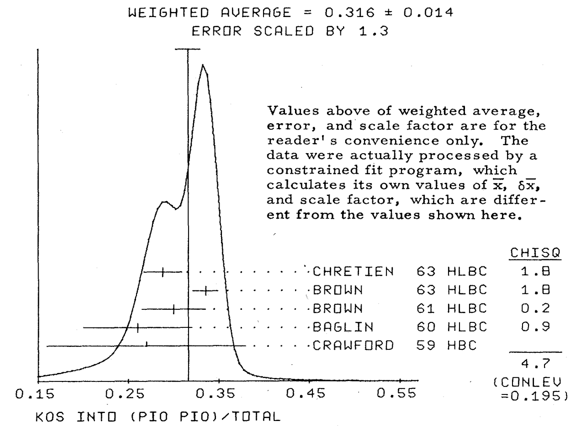

Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\overline{x}$, $\delta\overline{x}$, and scale factor, which are different from the values shown here.

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R4      (KOS INTO PI+ PI- PIO, CP VIOLATING)/(KOL INTO PI+ PI- PIO)
R4       TEST OF CP VIOLATION - SEE TEXT SECTION VI B.3A FOR DEFINITIONS
R4       CPT ASSUMED VALID - (I.E. RE(A)=0) - ONLY (IMA)**2 QUOTED HERE
R4       18   (3.8)  OR LESS  CL=.90   ANDERSON  65 HBC                      10/69
R4             0.45  OR LESS  CL=.90   BEHR      66 HLBC                      8/66
R4       53   (1.7)  OR LESS  CL=.90   WEBBER    70 HBC                       8/70
R4 C     71    0.8   OR LESS  CL=.90   WEBBER    70 HBC                       8/70
R4       99    1.2   OR LESS  CL=.90   CHO       71 DBC                       4/71
R4   J   98   (1.0)  OR LESS  CL=.90   JAMES     71 HBC                       6/71
R4   M   50   (1.2)  OR LESS  CL=.95   MEISNER   71 HBC    CL=.9 NOT AVAIL.  2/71
R4 J    180    0.66  OR LESS  CL=.90   JAMES     72 HBC                       1/73
R4       99    1.2   OR LESS  CL=.90   JONES     72 OSPK                     10/72
R4      384    0.12  OR LESS  CL=.90   METCALF   72 ASPK                      2/74
R4      148    0.71  OR LESS  CL=.90   MALLARY   73 OSPK   RE(A)=-.05+-.17    8/73
R4      192    1.2   OR LESS  CL=.90   BALDOCEOL 75 HLBC                     12/75
R4 C     THIS IS THE COMBINED RESULT OF ANDERSON 65 AND WEBBER 70
R4 J     JAMES 72 IS A FINAL RESULT WHICH INCLUDES JAMES 71.                 11/73
R4  M    THESE AUTHORS FIND REAL(A)= 2.75+-.65, ABOVE VALUE AT RE(A)=0        2/71

R5      KOS INTO (MU+ MU-)/CHARGED (UNITS 10**-5)           (P3)/(P1)
R5            10.0   OR LESS  CL=.90   BOTT-BODE 67 OSPK                      8/67
R5            20.0   OR LESS  CL=.90   BOHM      69 OSPK                      2/71
R5             1.07  OR LESS  CL=.90   HYAMS     69 OSPK                     10/69
R5    S       32.6   OR LESS  CL=.90   STUTZKE   69 OSPK                      5/69
R5             0.047 OR LESS  CL=.90   GJESDAL   73 ASPK                      7/73
R5    S  VALUE CALCULATED BY US, USING 2.3 INSTEAD OF 1 EVENT, 90 PERC.CL

R6      KOS INTO (PI+ PI- GAMMA)/(PI+ PI-) (UN.10**-3)   (P5)/(P1)
R6       27        NO RATIO GIVEN      BELLOTTI  66 HBC     PG GT 50 MEV/C   10/69
R6       10     3.3       1.2          WEBBER    70 HBC     PG GT 50 MEV/C   10/69
R6 B            2.8       0.6          BURGUN    73 HBC     PG GT 50 MEV/C   11/73
R6 C     .29   (3.0)     (0.6)         BOBISUT   74 HLBC    PG GT 40 MEV/C   12/75
R6    T         2.68      0.15         TAUREG    76 SPEC    PG GT 50 MEV/C    6/77
R6 B     BURGUN 73 ESTIMATES THAT DIRECT EMISSION CONTRIBUTION IS .3+-.6 .   11/73
R6 C     BOBISUT 74 NOT INCLUDED IN AVERAGE BECAUSE P(GAMMA) CUT DIFFERS.     1/76
R6 C     ESTIMATES DIRECT EMISSION CONTRIBUTION TO BE 0.5 OR LESS, CL=.95.    1/76
R6    T  TAUREG 76 FIND DIRECT EMISSION CONTRIB LT .06,CL=.90.                 6/77
R6          . . . . . . . . . .
R6  AVG         2.70      0.14     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6  STUDENT     2.70      0.16     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R7      KOS INTO (E+ E-)/CHARGED (UNITS 10**-5)             (P4)/(P1)
R7            50.0   OR LESS  CL=.90   BOHM      69 OSPK                      2/71

R8      KOS INTO 2 GAMMA/TOTAL (UNITS 10**-3)               (P6)
R8 R     0    21.0   OR LESS  CL=.90   BANNER    69 OSPK                     12/71
R8 R     0     2.2   OR LESS  CL=.90   REPELLIN  71 OSPK                     12/71
R8 R     0     0.71  OR LESS  CL=.90   BANNER    72 OSPK                      8/72
R8       0     2.0   OR LESS  CL=.90   MORSE     72 DBC                       2/72
R8       0     0.4   OR LESS  CL=.90   BARMIN2   73 HLBC                      2/74
R8 R     THESE LIMITS ARE FOR MAXIMUM INTERFERENCE IN KS-KL TO 2 GAMMAS      12/71

R9      (KOS INTO PI+ PI- PIO, CP CONSERVING)/(KOL INTO PI+ PI- PIO)
R9      384    0.42  OR LESS  CL=.90   METCALF   72 ASPK                     11/72

R10     (KOS INTO 3PIO,CP VIOLATING)/(KOL INTO 3PIO)
R10     SEE COMMENTS UNDER BRANCHING RATIO R4
R10      22    1.2   OR LESS  CL=.90   BARMIN1   73 HLBC                     11/73
R10  G         0.28  OR LESS  CL=.90   GJESDAL   74 SPEC                     11/75
R10  G  GJESDAL 74 USES K2PI, KMU3 AND KE3 DECAY RESULTS AND UNITARITY.      11/75
R10  G  CALCULATES ABS(ETA000)=.26+-.20.  WE CONVERT TO CL=.90 UPPER LIMIT. 11/75

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REFERENCES FOR KOS


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BOLDT     58 PRL    1  150       E BOLDT,D O CALDWELL,Y PAL                  (MIT)
CRAWFORD  59 PRL    2  266       CRAWFORD,CRESTI,DOUGLASS,GOOD,TICHO + (LRL)

BAGLIN    60 NC    18 1043       BAGLIN,BLOCH,BRISSON,HENNESSY +          (EPOL)
BOWEN     60 PR   119 2030       BOWEN,HARDY,REYNOLDS,SUN,MOORE+   (PRIN+BNL)
COLUMBIA  60 ROCH CONF 727       M SCHWARTZ +                         (COLUMBIA)

BROWN     61 NC    19 1155       BROWN,BRYANT,BURNSTEIN,GLASER,KADYK+ (MICH)
ANDERSON  62 CERN CONF 836       J A ANDERSON,F S CRAWFORD +               (LRL)
BERTANZA  62  PREPRINT D105      BERTANZA,CONNOLLY,CULWICK,EISLER +       (BNL)
    UNPUBLISHED, BUT RECERTIFIED BY AUTHORS, AUGUST 66.

CHRETIEN  63 PR   131 2208       CHRETIEN+      (BRANDEIS+BROWN+HARVARD+ MIT)
BROWN     63 PR   130  769       BROWN,KADYK,TRILLING,ROE +          (LRL+MICH)
KREISLER  64 PR   136 B 1074     M KREISLER,O OVERSETH,J CRONIN   (PRINCETON)
ANDERSON  65 PRL  14 475         +CRAWFOR,GOLDEN,STERN,BINFORD +   (LRL+WISC)

ALFF-STE  66 PL 21 595           ALFF-STEINBERGER,HEUER,KLEINKNECHT + (CERN)
AUERBACH  66 PR 149 1052         AUERBACH,DOBBS,LANDE,MANN,SCIULLI+     (PENN)
    ALSO  65 AUERBACH
BALTAY    66 PR 142    932       BALTAY,SANDWEISS,STONEHILL +       (YALE+BNL)
BEHR      66 PL    22  540       BEHR,BRISSON,PETIAU+ (EPOL,MILA,PADO,ORSAY)
BELLOTTI  66 NC 45A 737          +PULLIA,BALDO-CEOLIN +            (MILAN+PADUA)
BOTT-BOD  66 PL    23 277        BOTT-BODENHAUSEN,DE BOUARD +             (CERN)
KIRSCH    66 PR   147  939       L KIRSCH,P SCHMIDT                   (COLUMBIA)
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Stable Particles

K_S^0, K_L^0

Data Card Listings

For notation, see key at front of Listings.


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BOTT-BOD 67 PL 24B 194          BOTT-BODENHAUSEN,DE BOUARD,CASSEL+   (CERN)
DCNALD   68 PL 27B  58          DONALD,EDWARDS,NISAR+ (LIVP,CERN,IPNP,CDEF)
HILL     68 PR 171 1418         HILL,ROBINSCN,SAKITT +        (BNL,CARNEGIE)

BANNER   69 PR 188 2033         +CRONIN,LIU,PILCHER              (PRINCETON)
BOHM     69 THESIS              A. BOHM                               (AACH)
BOZOKI   69 PL 30B 498          +FENYVES,GOMBOSI,NAGY,SURANYI+    (BUDAPEST)
DOYLE    69 UCRL 18139-THESIS   J.C. DOYLE                             (LRL)
GOBBI    69 PRL 22 682          GOBBI,GREEN,HAKEL,MOFFETT,ROSEN+(ROCHESTER)
HYAMS    69 PL  29B 521         +KOCH,POTTER,VON LINDERN,LORENZ+ CERN(MPIM)
MORFIN   69 PRL    23  660      MORFIN,SINCLAIR                       (MICH)
STUTZKE  69 PR    177  2009     +ABASHIAN,JONES,MANTSCH,ORR,SMITH(ILLINCIS)

MOFFETT  70 BAPS 15 512         +GOBBI,GREEN,HAKEL,ROSEN         (ROCHESTER)
WEBBER   70 PR D1 1967          +SOLMITZ,CRAWFORD,ALSTON-GARNJOST     (LRL)
   ALSO  69 UCRL 19226 THESIS   B R WEBBER                             (LRL)

BALTAY   71 PRL 27 1678         +BRIDGEWATER,COOPER,GERSHWIN,HABIBI+ (CGLU)
   ALSO  71 NEVIS-187 THESIS    WILLIAM A. COOPER                 (COLUMBIA)
CHO      71 PR D3 1557          +DRALLE,CANTER,ENGLER,FISK+ (CARN+BNL+CASE)
JAMES    71 PL 35B 265          +MONTANET,PAUL,PAULI+       (CERN+SACL+OSLO)
MEISNER  71 PR D3 59            +MANN,HERTZBACH,KOFLER +    (MASA+BNL+YALE)
REPELLIN 71 PL 36B 603          +WOLFF,CHOLLET,GAILLARD,JANE+    (ORSA+CERN)

ALITTI   72 PL 39B 568          J ALITTI,E LESQUOY,A MULLER         (SACLAY)
BANNER   72 PRL 29 237          +CRONIN,HOFFMAN,KNAPP,SHOCHET    (PRINCETON)
JAMES    72 NP B49 1            +MONTANET,PAUL,SAETRE+      (CERN+SACL+OSLO)
JONES    72 NC 9A 151           +ABASHIAN,GRAHAM,MANTSCH,ORR,SMITH+   (ILL)

METCALF  72 PL 40B 703          +NEUHOFER,NIEBERGALL+        (CERN+IPN+WIEN)
MORSE    72 PRL 28 388          +NAJENBERG,BIERMAN,SAGER+    (COLO+PRIN+UMD)
NAGY     72 NP B47 94           +TELBISZ,VESZTERGOMBI             (BUDAPEST)
   ALSO  69 PL 30B 498          BOZOKI,FENYVES,GOMBOSI,NAGY+      (BUDAPEST)
SKJEGGES 72 NP B48 343          SKJEGGESTAD,JAMES,MONTANET+(OSLO+CERN+SACL)

BARMIN1  73 PL 46B 465          +BARYLOV,DAVIDENKO,DEMIDOV+           (ITEP)
BARMIN2  73 PL 47B 463          +BARYLOV,DAVIDENKO,DEMIDOV+           (ITEP)
BURGUN   73 PL 46B 481          +BERTRANET,LESQUOY,MULLER,PAULI+(SACL+CERN)
FACKLER  73 PRL 31 847          +FRISCH,MARTIN,SMOOT,SOMPAYRAC         (MIT)
GJESDAL  73 PL 44B 217          +PRESSER,STEFFEN,STEINBERGER+    (CERN+HEID)
HILL     73 PR D8 1290          +SAKITT,SAMIOS,BURRIS,ENGLER+     (BNL+CARN)
MALLARY  73 PR D7 1953          +BINNIE,GALLIVAN,GOMEZ,PECK,SCIULLI+   (CIT)

BOBISUT  74 LNC 11 646          +HUZITA,MATTIOLI,PUGLIERIN            (PADO)
COWELL   74 PR D10 2083         +LEE-FRANZINI,ORCUTT,FRANZINI + (STON+COLU)
GEWENIGE 74 PL 48B 487          GEWENIGER,GJESDAL,PRESSER+       (CERN+HEID)
GJESDAL  74 PL 52B 119          +PRESSER,STEFFEN,STEINBERGER +   (CERN+HEID)

BALDOCEO 75 NC 25A 688          BALDO-CEOLIN,BOBISUT,CALIMANI+   (PADO+WISC)
CARITHER 75 PRL 34 1244         CARITHERS,MODIS,NYGREN,PUN +     (COLU+NYU)
ARCNSON  76 NC 32A 236          +MCINTYRE,ROEHRIG +       (WISC+EFI+UCSD+ILLC)
EVERHART 76 PR D14 661          +KRAUS,LANDE,LONG,LOWENSTEIN +        (PENN)
TAUREG   76 PL 65B 92           +ZECH,DYDAK,NAVARRIA+       (HEID+CERN+DORT)

                                PAPERS NOT REFERRED TO IN DATA CARDS

BIRGE    60 ROCH CCNF 601       R W BIRGE,P P ELY +         (LRL+WISCONSIN)
MULLER   60 PRL   4  418        MULLER,BIRGE,FOWLER,GOOD,PICCIONI+(LRL+BNL)
FITCH    61 NC   22 1160        V FITCH,P PIROUE,R PERKINS       (PRIN+LASL)
GOOD     61 PR  124 1223        GOOD,MATSEN,MULLER,PICCIONI +          (LRL)

CRAWFORD 62 CERN CCNF 827       F S CRAWFORD                           (LRL)
AUERBACH 65 PRL 14 192          AUERBACH,LANDE,MANN,SCIULLI,UTO +     (PENN)
TRILLING 65 UCRL 16473          GEORGE H TRILLING                      (LRL)
   UPDATED FRCM 1965 ARGONNE CONF., PAGE 115.
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K_L^0

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            13  LONG-LIVED NEUTRAL K(498, JP=0-) I=1/2

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              13  (KOL) - (KOS) MASS DIFFERENCE
   WE GIVE (KOL-KOS MASS DIFFERENCE / HBAR) IN UNITS OF 10**10 SEC-1

D  TX        (2.20)   (0.35)          FITCH     61 CNTR
D   X        (0.84)   (0.29)   (0.22)GOOD       61 HLBC
D  TXC       (1.02)   (0.23)          CAMERINI  62 HLBC                      8/67
D  TX        (0.55)   (0.24)          AUBERT    65 HLBC                      6/66
D   X        (0.26)   (0.36)   (0.26)BALDO-CEO  65 HLBC   ASSUMES CP CONS.
D  TXA       (0.64)   (0.12)          CHRISTENS 65 OSPK                      6/66
D  TX        (0.70) OR LESS           FITCH     65 OSPK   CF. MEISNER 66     7/66
D   V   130  (0.89)   (0.15)          VISHNEVSK 65 OSPK   CU AND AL REGEN    8/67
D   X        (0.514)  (0.039)         ALFF-STEI 66 OSPK                      6/66
D   X    84  (0.42)   (0.24)   (0.36) BALDO-CEO 66 HLBC   KO+N INTO HYPER.   8/67
D   B        (0.531)  (0.027)         BOTT-BODE 66 OSPK   C REGEN            9/66
D  TX    77  (0.58)   (0.17)          CAMERINI  66 HBC, DBC KO+N INTO HYPER  8/67
D   N    72  (+0.64)  (0.18)          CANTER    66 DBC    KO SCATTER IN D2  11/66
D   X    95  (0.62)   (0.10)   (0.16) CHANG     66 HBC    KO+P INTO HYPER.   8/67
D   X        (0.81)   (0.17)          FUJII     66 OSPK   IRON REGENERATOR   9/66
D   X    59  (0.74)   (0.34)          MEISNER1  66 HBC                       6/66
D          + SIGN FAVORED             MEISNER2  66 HBC                       9/66
D   X        (0.38)   (0.16)          JOVANOVIC 66 OSPK   C+URANIUM REGEN.  11/66
D  TX   136  (+0.64)  (0.19)          CANTER    67 DBC    KO+D INTO HYPER.  11/67
D   X        (0.65)   (0.11)          MISCHKE   67 OSPK                    .11/67
D   X   590  (0.59)   (0.13)          BALATZ    68 OSPK   AL REGENERATOR     3/68
D   X        (0.520)  (0.044)         CARNEGIE  68 HBC    GAP METHOD         3/68
D  TX        (+0.487) (0.046)         MELHOP    68 OSPK   ST.STEEL REGEN     6/68
D  BX        (0.547)  (0.024)         BOTT-BODE 69 OSPK   C REGEN            1/71
D  FX        (0.555)  (0.020)         FAISSNER  69 ASPK   REGEN IN CU       10/69
D             0.542    0.006          CULLEN    70 CNTR                      1/71
D   R        (0.542)  (0.006)         ARONSCN   70 ASPK   GAP METHOD         1/71
D   X        (0.481)  (0.052)  (0.075)BALATS    71 OSPK                      9/71
D   R        (0.534)  (0.007)         CARNEGIE  71 ASPK   GAP METHOD         8/71
D  TH   119  (+0.67)  (0.14)          HILL      71 DBC                      10/71
D   S  1757  (0.557)  (0.038)         FACKLER   73 OSPK                     11/73
D             0.5340   0.0030         GEWENIG3  74 SPEC   GAP METHOD        11/75
D             0.5334   0.0040         GJESDAL   74 SPEC   CHG ASYMMETRY     11/75
D            . . . . . . . . .
D   AVG       0.5349   0.0022  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D   STUDENT   0.5348   0.0025  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                COMMENTS
D   X   NO ATTEMPT HAS BEEN MADE TO CORRECT OLDER EXPERIMENTS WITH LARGE   11/75
D   X   ERRORS FOR THE SUBSEQUENT CHANGES IN THE KOS MEAN LIFE OR IN ETA+-. 2/76
D  T    A KOS MEAN LIFE OF 0.862 10**-10 SEC WAS USED IN CONVERTING THE     1/71
D  T    MASS DIFFERENCE FROM UNITS OF INVERSE KOS MEAN LIVES TO ABSOLUTE    1/71
D  T    UNITS. VALUES NOT BEARING THIS FOOTNOTE EITHER WERE GIVEN IN        1/71
D  T    ABSOLUTE UNITS OR WERE CONVERTED USING THE AUTHORS' VALUE OF THE    1/71
D  T    KOS MEAN LIFE.                                                      1/71
D    C  CAMERINI 62 VALUE CHANGED FROM 1.7 (SEE TABLE 1 OF CAMERINI 66)     8/67
D    A  CHRISTENSON 65 CORRECTED FOR INTERFERENCE BY FITCH 65 FOOTNOTE.     1/71
D   V   VISHNEVSKY 65 NOT CORRECTED FOR INTERFERENCE EFFECTS.               3/68
D   N   CANTER 66 ERROR IGNORES UNCERTAINTY OF PHASE SHIFTS.  THESE EVENTS 10/71
D   N   ARE USED IN HILL 71.                                               10/71
D  B    BOTT-BODENHAUSEN 69 IS A REEVALUATION OF BOTT-BODENHAUSEN 66.       1/71
D  F    FAISSNER 69 HAS ADDNL. SYSTEMATIC ERROR LESS THAN TWO PERCENT.      1/71
D   R   ARONSON 70 AND CARNEGIE 71 USE KOS MEAN LIFE=.862+-.006 E-10 SEC.  11/75
D   R   WE HAVE NOT ATTEMPTED TO ADJUST THESE VALUES FOR THE SUBSEQUENT     2/76
D   R   CHANGE IN THE KOS MEAN LIFE OR IN ETA+-.                            2/76
D   H   HILL 71 PRIMARY RESULT IS THAT DM IS POSITIVE.                     10/71
D   H   THE MAGNITUDE MAY HAVE AN ADDITIONAL SYSTEMATIC ERROR OF ABOUT 0.12 10/71
D   S   NOT AVERAGED BECAUSE ERROR IS LARGE AND SYSTEMATICS NOT DISCUSSED.  2/76

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              13  KOL MEAN LIFE (UNITS 10**-8 SEC)

T        KOL MEAN LIFE
T       34    8.1      3.2      2.4   BARDON     58 CNTR
T       ASSUMED DS=DQ AND DELTA I=1/2 CRAWFORD   59 HBC
T       15    5.1      2.4      1.3   DARMON     62 FBC
T             5.3      0.6            FUJII      64 OSPK
T     1700    6.1      1.5      1.2   ASTBURY3   65 CNTR
T             5.15     0.14           DEVLIN     67 CNTR
T   L        (5.0)    (0.5)           LOWYS      67 HLBC
T      .4M    5.154    0.044          VOSBURGH   72 CNTR                   2/71
T   L   SUM OF PARTIAL DECAY RATES.
T          . . . . . . . . .
T   AVG       5.158    0.042    0.042  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T   STUDENT   5.158    0.046    0.045  AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
T   FIT       5.183    0.040  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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              13  KOL PARTIAL DECAY MODES

                                                      DECAY MASSES
P1     KOL INTO 3PIO                    TAU 0 PRIME   134+ 134+ 134
P2     KOL INTO PI+ PI- PIO             TAU 0         139+ 139+ 134
P3     KOL INTO PI MU NEUTRINO          KL MU3        139+ 105+   0
P4     KOL INTO PI E NEUTRINO           KL E3         139+  .5+   0
P5     KOL INTO PI+ PI-                 KL PI+ PI-    139+ 139
P6     KOL INTO MU+ MU-                 KL 2MU        105+ 105
P7     KOL INTO E+ E-                   KL 2E          .5+  .5
P8     KOL INTO E MU                    KL EMU         .5+ 105
P9     KOL INTO TWO GAMMAS              KL 2GAMMA       0+   0
P10    KOL INTO PI+ PI- GAMMA           KL PI+-G      139+ 139+   0
P11    KOL INTO PIO PIO                 KL 2PIO       134+ 134
P12    KOL INTO PI E NEU GAMMA          KL E3GAM      139+  .5+   0+   0
P13    KOL INTO PIO TWO GAMMAS          KL PI2GAMMA   134+   0+   0
P14    KOL INTO E+ E- GAMMA             KL 2EGAM       .5+  .5+   0
P15    KOL INTO MU+ MU- GAMMA           KL 2MUGAM     105+ 105+   0
P16    KOL INTO MU+ MU- PIO             KL 2MUPIO     105+ 105+ 134
P17    KOL INTO PI+ PI- E+ E-           KL 2PI2E      139+ 139+  .5+  .5
P18    KOL INTO PIO PI+- E-+ NEU        KL 2PIENEU    134+ 139+  .5+   0
P19    KOL INTO (PI MU ATOM) NEU        KL (PIMU)NEU

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                NEUTRAL K CONSTRAINED FIT
          OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING
          RATICS USES 64 DATA POINTS TO DETERMINE SIX                      3/78
          QUANTITIES.  OVERALL FIT HAS CHI-SQUARED=69.8                    3/78

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P11
P 1	.2147+-.0073					
P 2	-.5340	.1239+-.0018				
P 3	-.5709	.1869	.2701+-.0048			
P 4	-.6711	.2212	-.1788	.3884+-.0054		
P 5	-.3361	.4867	.1379	.1627	.0020+-.0001	
P11	.1719	-.1061	-.1115	-.1312	-.0665	.0009+-.0002

FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e., $G_i \equiv \Gamma_i = \Gamma_{total} P_i$, in appropriate units. In analogy to the matrix above, the diagonal elements are $G_i \pm \delta G_i$, where $\delta G_i = \sqrt{\langle \delta G_i \delta G_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta G_i \delta G_j \rangle / (\delta G_i \cdot \delta G_j)$. Note that, because of the error in Γ_{total}, the errors and correlations here are not directly derivable from those above.

	G 1	G 2	G 3	G 4	G 5	G11
G 1	.0414+-.0015					
G 2	-.3285	.0239+-.0004				
G 3	-.3816	.2970	.0521+-.0010			
G 4	-.4277	.3439	-.0028	.0749+-.0011		
G 5	-.2206	.5284	.2112	.2440	.0004+-.0000	
G11	.1814	-.0706	-.0798	-.0896	-.0471	.0002+-.0000

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              13  KOL DECAY RATES

W1     KOL INTO PIO PIO PIO (UNITS 10**6 SEC-1)          (G1)
W1      54    5.22     1.03     0.84  BEHR       66 HLBC    ASSUMES CP      8/66
W1          . . . . . . . . .
W1  FIT       4.14     0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

K^0_L

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W2       KOL INTO PI+ PI- PO (UNITS 10**6 SEC-1)              (G2)
W2       18    3.26    0.77              ANDERSON  65 HBC                              8/66
W2       14    1.4     0.4               FRANZINI  65 HBC                              6/66
W2      136    2.62    0.28      0.27  BEHR      66 HLBC      ASSUMES CP              8/66
W2       53    2.20    0.35              WEBBER    70 HBC       ASSUMES CP             10/71
W2       99    2.71    0.28              CHO       71 DBC       ASSUMES CP              4/71
W2 J     98   (2.5)   (0.3)              JAMES     71 HBC       ASSUMES CP              6/71
W2       50    2.12    0.33              MEISNER   71 HBC       ASSUMES CP             10/71
W2 J    180    2.35    0.20              JAMES     72 HBC       ASSUMES CP              1/73
W2      192    2.32    0.13      0.15  BALDOCEOL 75 HLBC      ASSUMES CP              1/76
W2       IN THE OVERALL FIT THIS RATE IS WELL DETERMINED BY THE MEAN LIFE AN
W2       THE BRANCHING RATIO R2. FOR THIS REASON THE DISCREPANCY BETWEEN THE
W2       W2 MEASUREMENTS DOES NOT AFFECT THE SCALE FACTOR OF THE OVERALL FIT
W2 J     JAMES 72 IS A FINAL MEASUREMENT AND INCLUDES JAMES 71.                        11/73
W2               . . . . . . . . .
W2  AVG          2.34    0.11    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
W2  STUDENT      2.35    0.10    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
W2  FIT          2.391   0.038   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                                 (SEE IDEOGRAM BELOW )
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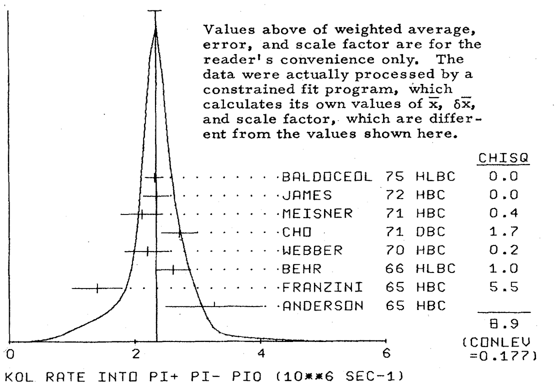
WEIGHTED AVERAGE = 2.34 ± 0.11
ERROR SCALED BY 1.2

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W3       KOL INTO PI E NEUTRINO (UNITS 10**6 SEC-1)         (G4)
W3               7.52    0.85     0.72  AUBERT     65 HLBC    DS=DQ,CP ASSUMED  8/67
W3      620      7.81    0.56           CHAN       71 HBC                        2/72
W3               . . . . . . . . .
W3  AVG          7.71    0.46    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W3  STUDENT      7.71    0.49    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
W3  FIT          7.49    0.11    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

W4       KOL INTO CHARGED (3-BODY) (UNITS 10**6 SEC-1)      (G2+G3+G4)
W4       98     15.1     1.9             AUERBACH   66 OSPK                          8/67
W4               . . . . . . . . .
W4  FIT         15.09    0.17    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

W5       KOL INTO LEPTONIC (KMU3+KE3) (UNITS 10**6 SEC-1) (G3+G4)
W5    D 109      9.85    1.15      1.05  FRANZINI   65 HBC                           2/72
W5  C   335    (10.3)   (0.8)            HILL       67 DBC     K+N TO KO P           8/67
W5    D 393     11.6     0.9             CHO        70 DBC     K+N TO KOP           10/70
W5    D 252     13.1     1.3             WEBBER     71 HBC     K- P TO KOBAR N       2/72
W5    D 410     12.4     0.7             BURGUN     72 HBC     K+P TO KOPPI+         1/73
W5    D 126      8.47    1.69            MANN       72 HBC     K- P TO KOBAR N       9/72
W5  C   CHO 70 INCLUDES EVENTS OF HILL 67
W5    D  ASSUMES DS=DQ RULE
W5               . . . . . . . . .
W5  AVG         11.60    0.65    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
W5  STUDENT     11.66    0.54    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
W5  FIT         12.70    0.15    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                                 (SEE IDEOGRAM BELOW )
```
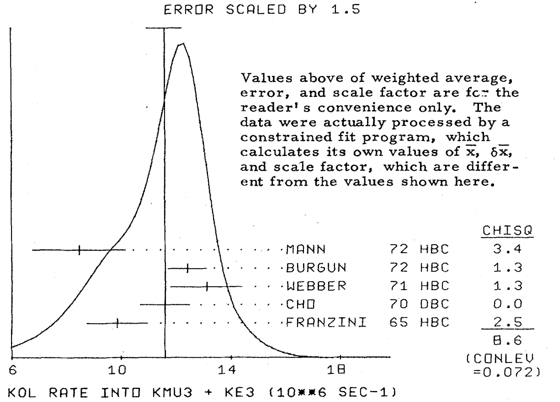

WEIGHTED AVERAGE = 11.60 ± 0.65
ERROR SCALED BY 1.5

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W6       KOL INTO PI MU NEUTRINO UNITS 10**6 SEC-1)          (G3)
W6       19      4.54    1.24     1.08  LOWYS       67 HLBC                           8/67
W6               . . . . . . . . .
W6  FIT          5.211   0.100   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
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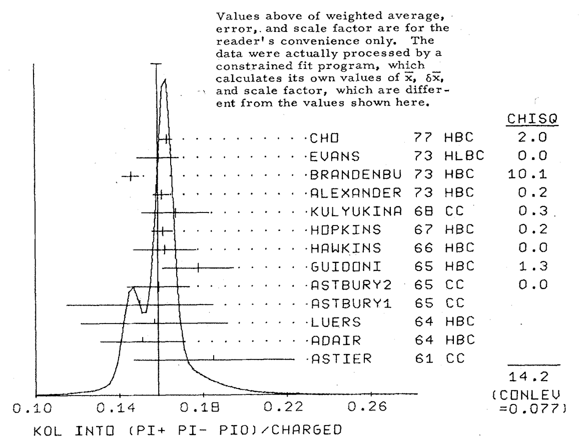
                 13  KOL BRANCHING RATIOS

R1      KOL INTO (PIO PIO PIO)/CHARGED                                  (P1)/(P2+P3+P4)
R1       24     0.24     0.08              ANIKINA    64 CC                            6/66
R1      549     0.251    0.014             BUDAGOV    68 HLBC    ORSAY MEASUR.        10/68
R1      444     0.277    0.021             BUDAGOV    68 HLBC    EC. POLYTEC.MEAS     10/68
R1       29     0.31     0.07       0.06  KULYUKINA  68 CC                            2/71
R1               . . . . . . . . .
R1  AVG         0.260    0.011   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT     0.260    0.013   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT         0.274    0.012   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2      KOL INTO (PI+ PI- PIO)/CHARGED                                  (P2)/(P2+P3+P4)
R2       59     0.185    0.038             ASTIER     61 CC                            8/66
R2       79     0.151    0.020             ADAIR      64 HBC                           8/66
R2       75     0.157    0.03       0.04  LUERS      64 HBC                           8/66
R2       66     0.15     0.03       0.04  ASTBURY1   65 CC                            8/66
R2      326     0.159    0.015             ASTBURY2   65 CC                            6/66
R2      566     0.178    0.017             GUIDONI    65 HBC                           6/66
R2     1729    (0.144)  (0.004)            HOPKINS    65 HBC     SEE HOPKINS 67        6/66
R2      126     0.162    0.015             HAWKINS    66 HBC                           6/66
R2              0.161    0.005             HOPKINS    67 HBC                           8/67
R2     1402     0.167    0.016             KULYUKINA  68 CC                            2/71
R2     1590     0.1605   0.0038            ALEXANDER  73 HBC                           1/74
R2     3200     0.146    0.004             BRANDENBU  73 HBC                           1/74
R2      558     0.159    0.010             EVANS      73 HLBC                          1/73
R2     6499     0.163    0.003             CHO        77 HBC                          11/77
R2               . . . . . . . . .
R2  AVG         0.1587   0.0024  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R2  STUDENT     0.1600   0.0022  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2  FIT         0.1584   0.0020  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                                 (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.1587 ± 0.0024
ERROR SCALED BY 1.3

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R3      KOL INTO (PI MU NEUTRINO)/CHARGED                               (P3)/(P2+P3+P4)
R3  C   251    (0.356)  (0.07)             LUERS      64 HBC
R3  C   172    (0.39)   (0.08)     (0.10) ASTBURY1   65 CC                            7/66
R3  C   330    (0.335)  (0.055)            KULYUKINA  68 CC                            2/71
R3  C THIS MODE NOT MEASURED INDEPENDENTLY FROM R2 AND R4
R3               . . . . . . . . .
R3  FIT         0.3452   0.0051 FROM FIT

R4      KOL INTO (PI E NEUTRINO)/CHARGED                                (P4)/(P2+P3+P4)
R4       24     0.46     0.11              NEAGU      61 CC                            2/76
R4      153     0.487    0.05              LUERS      64 HBC
R4      202     0.46     0.08       0.10  ASTBURY1   65 CC                            7/66
R4      500     0.498    0.052             KULYUKINA  68 CC                            2/71
R4               . . . . . . . . .
R4  AVG         0.485    0.032   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4  STUDENT     0.485    0.034   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R4  FIT         0.4964   0.0051 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5      KOL INTO (PI E NEU)/((PI E NEU)+(PI MU NEU))            (P4)/(P3+P4)
R5      320     0.415    0.120             ASTIER     61 CC
R5               . . . . . . . . .
R5  FIT         0.5898   0.0059 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6      KOL INTO (PI+ PI- PIO)/TOTAL                                    (P2)
R6
R6               . . . . . . . . .
R6  FIT         0.1239   0.0018 FROM FIT

R7      KOL INTO (LEPTON PI NEUTRINO)/TOTAL                             (P3+P4)
R7
R7               . . . . . . . . .
R7  FIT         0.6584   0.0066 FROM FIT

R8      KOL INTO (2 GAMMA)/TOTAL (UN. 10**-4)                  (P9)
R8  C          (1.3)    (0.6)              CRIEGEE    66 OSPK                          8/66
R8       32     6.7      2.2               TODOROFF   67 OSPK    REPL.  CRIEGEE66     11/68
R8  K    33    (7.4)    (1.6)              CRONIN 1   67 OSPK                         11/67
R8       90     5.5      1.1               KUNZ       68 OSPK    NORM.TO 3PI(C+N)      2/71
R8       23     4.5      1.0               ENSTROM    71 OSPK    KOL 1.5-9 GEV/C       2/72
R8  R           5.0     (1.0)              REPELLIN   71 OSPK                         11/71
R8  B           4.54     0.84              BANNER2    72 OSPK                          8/72
R8  B   THIS VALUE USES (E00/E+-)**2=1.05+-0.14. IN GENERAL, S13R8 =                   8/72
R8  B   (4.32+-0.55)*(10**-4)*((E00/E+-)**2).                                          8/72
R8  R   ASSUMES REGEN AMPL IN COPPER AT 2GEV IS 22  MB. TO EVALUATE                   11/71
R8  R   FOR A GIVEN REGEN AMPL AND ERROR, MULTIPLY BY (REGEN AMPL/22MB)**2            11/71
R8  C     CRIEGEE 66 REPLACED BY TODOROFF 67                                          11/68
R8  K     CRONIN1 67 REPLACED BY KUNZ 68.                                              2/71
R8               . . . . . . . . .
R8  AVG          4.89    0.54    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  STUDENT      4.88    0.59    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
```

Stable Particles

K^0_L

Data Card Listings

For notation, see key at front of Listings.

```
R9      KOL INTO (PI+ PI-)/CHARGED (UNIT 10**-3)            (P5)/(P2+P3+P4)
R9  O   45   (2.0)     (0.4)            CHRISTENS 64 OSPK ETA +- = 1.95+-0.20  2/76
R9  O   54   (2.08)    (0.35)           GALBRAITH 65 OSPK ETA +- = 1.99+-0.16  2/76
R9  O        (1.93)    (0.26)           BASILE    66 OSPK ETA +- = 1.92+-0.13. 2/76
R9  O        (1.993)   (0.080)          BOTT-BODE 66 OSPK ETA +- = 1.95+-0.04  2/76
R9  M 4200   (2.60)    (0.07)           MESSNER   73 ASPK ETA +- = 2.23+-0.05  6/73
R9  O   OLD EXPERIMENTS EXCLUDED FROM FIT.  SEE SUBSECTION E+- BELOW FOR       2/76
R9  O   AVERAGE ETA+- OF THESE EXPERIMENTS AND FOR NOTE ON DISCREPANCY.        2/76
R9  M   FROM SAME DATA AS R27 MESSNER 73,BUT WITH DIFFERENT NORMALIZATION.     6/73
R9           . . . . . . . . . .
R9  FIT        2.589     0.060   FROM FIT

R10     KOL INTO (PI MU NEU)/(PI E NEU)                     (P3)/(P4)
R10            0.81      0.19           ADAIR     64 HBC                       6/66
R10            0.82      0.10           DEBOUARD  67 OSPK                     11/67
R10    273     0.7       0.2            HAWKINS   67 HBC                       8/67
R10            0.81      0.08           HOPKINS   67 HBC                       8/67
R10    770     0.71      0.05           BUDAGOV   68 HLBC                     10/68
R10 K         (0.67)    (0.13)          KULYUKINA 68 CC                      . 3/74
R10 B  569    (0.71)    (0.04)          BEILLIERE 69 HLBC                     10/69
R10   1309    (0.648)   (0.030)         EVANS     69 HLBC REPL. BY EVANS 73    1/73
R10   3548     0.68      0.08           BASILE    70 OSPK                     10/70
R10   6700     0.741     0.044          BRANDENBU 73 HBC                       1/74
R10   1309     0.662     0.030          EVANS     73 HLBC                      1/73
R10    10K     0.662     0.037          WILLIAMS  74 ASPK                     10/74
R10 K   KULYUKINA 68 R10 IS NOT MEASURED INDEPENDENTLY FROM R2 AND R4.         1/74
R10 B  BEILLIERE 69 IS A SCANNING EXPT USING SAME EXPOSURE AS BUDAGOV 68
R10          . . . . . . . . . .
R10 AVG        0.695     0.019   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R10 STUDENT    0.695     0.021   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R10 FIT        0.695     0.017  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R11     KOL INTO (MU+MU-)/CHARGED (UNITS 10**-6)            (P6)/(P2+P3+P4)
R11          100.0    OR LESS           ANIKINA   65 CC                        6/66
R11          250.0    OR LESS  CL=.90   ALFF-STEI 66 OSPK                      9/66
R11            2.0    OR LESS  CL=.90   BOTT-BODE 67 OSPK                      8/67
R11           35.0    OR LESS  CL=.90   FITCH     67 OSPK                      3/68

R12     KOL INTO (PI+ PI- GAMMA)/TOTAL (UNITS 10**-3)       (P10)
R12           15.0    OR LESS           ANIKINA   65 CC                        6/66
R12       0    5.0    OR LESS           BELLOTTI  66 HLBC    GAM KE 40-130 MV  8/67
R12       1    3.0    OR LESS           NEFKENS   66 OSPK    GAM KE 120 MEV    6/66
R12            0.4    OR LESS  CL=.90   THATCHER  68 OSPK    GAM KE 20-170 MV  2/71
R12            3.2    OR LESS  CL=.90   BOBISUT   74 HLBC    GAM KE GT 40 MEV 12/75
R12  D  24     0.062     0.021          DONALDS1  74 SPEC                     10/74
R12            0.46   OR LESS  CL=.90   WOO       74 SPEC                     12/75
R12  D  USES KOL TO PI+PI-PIO/ALL KOL DECAYS = 0.126                          10/74

R13     KOL INTO (E+ E-)/CHARGED (UNITS 10**-6)             (P7)/(P2+P3+P4)
R13         1000.0    OR LESS           ANIKINA   65 CC                        6/66
R13          200.0    OR LESS  CL=.90   ALFF-STEI 66 OSPK                      6/66
R13           23.0    OR LESS  CL=.90   BOTT-BODE 67 OSPK                      8/67

R14     KOL INTO (E MU)/CHARGED (UNITS 10**-4)              (P8)/(P2+P3+P4)
R14           10.0    OR LESS           ANIKINA   65 CC                        6/66
R14            1.0    OR LESS  CL=.90   CARPENTER 66 OSPK                      8/66
R14            0.1    OR LESS  CL=.90   BOTT-BODE 67 OSPK                      8/67
R14            0.08   OR LESS  CL=.90   FITCH     67 OSPK                      3/68

R15     KOL INTO (E+ PI- NEU)/(E- PI+ NEU)
R15 O   97   (0.90)    (0.18)           NEAGU     61 CC
R15 O        (1.01)    (0.16)           LUERS     64 HBC                       8/66
R15 O  894   (0.99)    (0.023)          KULYUKINA 66 CC                        9/66
R15 O 1539   (1.06)    (0.05)           VERHEY    66 OSPK                      8/67
R15 O   LOW PRECISION EXPTS NOT AVERAGED.  FOR MORE PRECISE VALUE,
R15 O   SEE S13A2 (BENNETT 70, MARX 70)

R16     KOL INTO (MU+ PI- NEU)/(MU- PI+ NEU)
R16      1M    1.0081    0.0027         DORFAN    67 OSPK                     11/67
R16      SEE ALSO S13A2 AND S13AL IN THE CP VIOLATION SECTION                  2/71

R17     KOL INTO (PIO PIO)/TOTAL (UNITS 10**-3)             (P11)
R17 C    7   (1.2)     (1.5)     (1.2)  CRIEGEE   66 OSPK                      7/66
R17 C   CRIEGEE EXPT NOT DESIGNED TO MEASURE 2 PIO DECAY MODE
R17 G  189   (2.5)     (0.8)            GAILLARD  69 OSPK    E00=3.6+-0.6      5/69
R17 G   LATEST RESULT OF THIS EXPERIMENT GIVEN BY FAISSNER 7C R19              1/71
R17          . . . . . . . . . .
R17 FIT        0.94      0.18    FROM FIT

R18     KOL INTO (3PIO)/(PI+PI-PIO)                         (P1)/(P2)
R18    188     2.0       0.6            ALEKSANYA 64 FBC                       9/66
R18   1010     1.80      0.13           BUDAGOV   68 HLBC                     10/68
R18    883    (1.65)    (0.07)          BARMIN2   72 HLBC    ERROR STAT. ONLY  3/74
R18          . . . . . . . . . .
R18 AVG        1.81      0.13    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R18 STUDENT    1.81      0.14    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R18 FIT        1.733     0.076  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R19     KOL INTO (2PIO)/(3PIO) (UNITS 10**-2)               (P11)/(P1)
R19 C  109   (1.89)    (0.31)           CRONIN 1  67 OSPK    ETA00=4.9+-0.5    8/67
R19 C        (1.36)    (0.18)           CRONIN 2  67 OSPK    ETA00=3.92+-0.3  11/67
R19 C      CRONIN2 IS FURTHER ANALYSIS OF CRONIN1 ,NOW BOTH WITHDRAWN         11/68
R19     NO EVENTS SEEN                  BARTLETT  68 OSPK    SEE E00 BELOW    11/68
R19     57     0.46      0.11           BANNER    69 OSPK    ETA00=2.2+-0.3    2/72
R19 R  133    (1.31)    (0.31)          CENCE     69 OSPK    ETA00=3.7+-0.5   10/69
R19     29     0.37      0.08           BARMIN    70 HLBC    ETA00=2.02+-0.23 12/70
R19     30     0.32      0.15           BUDAGOV   70 HLBC    ETA00=1.9+-0.5   10/70
R19  F 172     0.90      0.30           FAISSNER  70 OSPK    ETA00=3.2+-0.5   12/70
R19  R 150     1.21      0.30           REY       76 OSPK    ETA00=3.8+-0.5    8/76
R19  F FAISSNER 70 CONTAINS SAME 2PIO EVENTS AS GAILLARD 69 R17
R19  R  CENCE 69 EVENTS ARE INCLUDED IN REY 76.                                1/77
R19          . . . . . . . . . .
R19 AVG        0.437     0.092   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
R19 STUDENT    0.425     0.065   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R19 FIT        0.437     0.083  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)
                        (SEE IDEOGRAM BELCW )

R20     KOL INTO (PI+ PI-)/(KE3 + KMU3) (UNITS 10**-3)   (P5)/(P3+P4)
R20 O  309   (2.51)    (0.23)           DEBOUARD  67 OSPK    ETA+-=2.00+-0.09  2/76
R20 O  525   (2.35)    (0.19)           FITCH     67 OSPK    ETA+-=1.94+-0.08  2/76
R20   2703     3.04      0.14           DEVOE     77 SPEC    ETA+-=2.25+-0.05 11/77
R20 O   OLD EXPERIMENTS EXCLUDED FROM FIT.  SEE SUBSECTION E+- BELOW FOR       2/76
R20 C   AVERAGE ETA+- OF THESE EXPERIMENTS AND FOR NOTE ON DISCREPANCY.        2/76
R20          . . . . . . . . . .
R20 FIT        3.076     0.075  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R21     KOL INTO (2GAMMA)/(3 PIO) (UNITS 10**-3)            (P9)/(P1)
R21     16     2.5       0.7            ARNOLD    68 HLBC    VACUUM DECAY     11/68
R21 $  BANNER 69 IS NEW EXPT. NOT TO BE CCNF WITH R8 OF CRONIN1 67             2/72
R21    115     2.24      0.28           BANNER    69 OSPK                     11/68
R21     28     2.13      0.43           BARMIN    71 HLBC                      8/71
R21          . . . . . . . . . .
R21 AVG        2.24      0.22    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R21 STUDENT    2.24      0.24    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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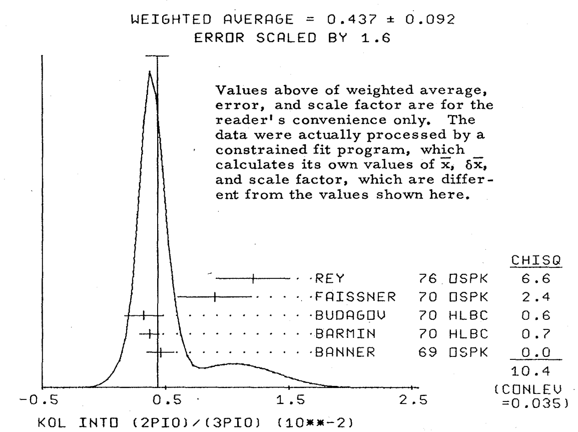


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R22     KOL INTO (MU+MU-)/(PI+PI-) (UNITS 10**-6)          (P6)/(P5)
R22      0  140.     OR LESS  CL=.90   FOETH     69 SPEC                    5/70
R22      0   18.     OR LESS  CL=.90   DARRIULAT 70 SPEC                   11/70
R22 A    0  (1.53)   OR LESS  CL=.90   CLARK     71 SPEC                    2/76
R22  C   9    5.8      2.3      1.5    CARITHERS 73 SPEC                    2/76
R22  F   3    4.2      5.1      2.6    FUKUSHIMA 76 SPEC                    2/76
R22     15    4.0      1.4      0.9    SHOCHET   79 SPEC                    7/79*
R22 A   CLARK 71 LIMIT RAISED FROM 1.2 E-06 BY FIELD 74 REANALYSIS.         2/76
R22 A   NOT IN AGREEMENT WITH SUBSEQUENT EXPTS. SO NOT AVERAGED.            2/76
R22  C  CARITFERS 73 ERRORS ARE AT CL=0.68, W.CARITHERS, PRIV.COMM. 1979.   2/76
R22  F  FUKUSHIMA 76 ERRORS ARE AT CL=90 PERCENT.                           2/76
R22          . . . . . . . . . .
R22 AVG       4.47      0.95     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R22 STUDENT   4.5       1.0      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R23     KOL INTO (E+ E- )/(PI+PI-) (UNITS 10**-5)          (P7)/(P5)
R23      0   10.0    OR LESS  CL=.90   FOETH     69 ASPK                    5/70
R23           0.10   OR LESS  CL=.90   CLARK     71 ASPK                    6/71

R24     KOL INTO (E MU)/(PI+PI-) (UNITS 10**-5)            (P8)/(P5)
R24           0.10   OR LESS  CL=.90   CLARK     71 ASPK                    6/71

R25     KOL INTO (PI E NEU GAM)/(KL E3) (UNITS 10**-2)     (P12)/(P3)
R25     10    3.3      2.0             PEACH     71 HLBC GAM KE GT 15 MEV   6/71

R26     KOL INTO (PIO TWO GAMMAS)/(3PIO) (UNITS 10**-3)    (P13)/(P1)
R26      0    1.1    OR LESS  CL=.90   BANNER    69 OSPK                    2/72

R27     KOL INTO (PI+ PI-)/TAU (UNITS 10**-2)              (P5)/(P2)        6/73
R27   4200    1.64     0.04            MESSNER   73 ASPK   ETA +- = 2.23    6/73
R27          . . . . . . . . . .
R27 FIT       1.635    0.036   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R28     KOL INTO (E+ E- GAMMA)/(3PIO) (UNITS 10**-4)       (P14)/(P1)
R28      0    1.3    OR LESS  CL=.90   BARMIN1   72 HLBC                    3/74

R29     KOL INTO (MU+ MU- GAMMA)/TOTAL (UNITS 10**-6)      (P15)           12/75
R29  D        7.81   OR LESS  CL=.90   DONALDS3  74 SPEC                    6/77
R29  D  USES KOL TO PI+PI-PIO/ALL KOL DECAYS = 0.126                        6/77

R30     KOL INTO (MU+ MU- PIO)/TOTAL   (UNITS 10**-5)      (P16)           12/75
R30  D        5.66   OR LESS  CL=.90   DONALDS3  74 SPEC                    6/77
R30  D  USES KOL TO PI+PI-PIO/ALL KOL DECAYS = 0.126                        6/77

R31     KOL INTO (PI+PI-E+E-) /TOTAL   (UNITS 10**-6)      (P17)           12/75
R31          30.     OR LESS           ANIKINA   73 STRC                    3/78
R31  D        8.81   OR LESS  CL=.90   DONALDSON 76 SPEC                    6/77
R31  D  USES KOL TO PI+PI-PIO/ALL KOL DECAYS = 0.126                        6/77

R32     KOL INTO (PIO PI+- E-+ NEU)/TOTAL (UNITS 10**-3) (P18)             12/75
R32  D        2.2    OR LESS  CL=.90   DONALDS3  74 SPEC                    6/77
R32  D  USES KOL TO PI+PI-PIO/ALL KOL DECAYS = 0.126                        6/77

R33     KOL INTO (PI MU ATOM) NEU/TOTAL (UNITS 10**-7)  (P19)               6/77
R33      18   SEEN                     COOMBES   76 WIRE                    6/77

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                       13  KOL ENERGY DEPENDENCE OF DALITZ PLOT

         RELATED TEXT SECTION VI B.1, APPENDIX I, AND MINI-REVIEW ON SLOPE
         PARAMETERS IN THE CHARGED K SECTION OF THE DATA CARD LISTINGS ABOVE

        MATRIX ELEMENT SQUARED = 1 + G*U + H*U**2 + J*V + K*V**2
        WHERE U=(S3-SO)/(MPI**2) AND V=(S1-S2)/(MPI+**2)

GTO     LINEAR COEFFICIENT G FOR KL --> PI+ PI- PIO MATRIX ELEMENT SQUARED
GTO Q    79    (0.55)    (0.23)          ADAIR     64 HBC  AV=-7.6 +- 1.7     3/71
GTO Q    77    (0.51)    (0.20)          LUERS     64 HBC  AV=-7.3 +- 1.6     3/71
GTO Q    66    (0.32)    (0.13)          ASTBURY1  65 CC   AV=-5.5 +- 1.5     3/71
GTO Q   310    (0.51)    (0.09)          ASTBURY2  65 CC   AV=-(7.3 +.6 -.8)  3/71
GTO Q   280    (0.64)    (0.17)          ANIKINA   66 CC   AV=-(8.2 +.9 -1.3) 3/71
GTO Q   126    (0.70)    (0.12)          HAWKINS   66 HBC  AV=-8.6 +- 0.7     3/71
GTO Q 1350     (0.649)   (0.044)         HOPKINS   67 HBC  AT=-0.294 +- .018 10/69
GTO Q 1198     (0.428)   (0.055)         NEFKENS   67 OSPK AU=-0.204 +- .025  3/71
GTO Q 2446     (0.400)   (0.045)         BASILE2   68 OSPK AT=-0.188 +- .020  3/71
GTO Q  29K     (0.650)   (0.012)         ALBROW    70 ASPK AY=-0.858+-.015    1/79*
GTO QB 36K     (0.593)   (0.022)         BUCHANAN  70 SPEC AU=-0.278 +- .010  2/76
GTO Q 4400     (0.664)   (0.056)         SMITH     70 OSPK AT=-0.306 +-0.024  1/79*
GTO Q  180     (0.50)    (0.11)          JAMES     72 HBC                     1/73
GTO Q 1486     (0.608)   (0.043)         KRENZ     72 HLBC AT=-0.277 +- .018 11/72
GTO Q  384     (0.688)   (0.074)         METCALF   72 ASPK AT=-0.31  +- .03  11/72
GTO Q          (0.612)   (0.032)         ALEXANDER 73 HBC                     2/76
GTO Q 3200     (0.73)    (0.04)          BRANDENBU 73 HBC                     1/74
GTO QC 20K     (0.619)   (0.027)         BISI      74 ASPK AT=-0.282 +- .011 10/74
GTO    509K     0.677     0.010          MESSNER   74 ASPK AY=-0.917+-.013    7/75
GTO Q  192     (0.69)    (0.07)          BALDOCEOL 75 HLBC                   12/75
GTO Q  56K     (0.590)   (0.022)         BUCHANAN  75 SPEC AU=-0.277 +- .010  7/75
GTO   H6499     0.681     0.024          CHO       77 HBC                    11/77
GTO    4709     0.620     0.023          PEACH     77 HBC                    11/77
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

K^0_L

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GTO Q   QUADRATIC DEPENDENCE REQUIRED BY SOME EXPERIMENTS (SEE SECTIONS
GTO Q   HTO AND KTO BELOW).  CORRELATIONS PREVENT US FROM AVERAGING RESULTS
GTO Q   OF FITS NOT INCLUDING G, H, AND K TERMS.
GTO  B  BUCHANAN 70 RESULT REVISED BY BUCHANAN 75 TO INCLUDE RADIATIVE COR.  2/76
GTO  B  AND TO USE MORE RELIABLE KL MOM.SPECT. OF 2ND EXPT.(HAD SAME BEAM).  2/76
GTO  C  BISI 74 VALUE COMES FROM QUADRATIC FIT WITH QUAD. TERM CONSISTENT   11/75
GTO  C  WITH ZERO.  GTO ERROR IS THUS LARGER THAN IF LINEAR FIT WERE USED.  11/75
GTO           . . . . . . . . .
GTO AVG       0.670     0.014    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
GTO STUDENT   0.6716    0.0100   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                 (SEE IDEOGRAM BELOW )
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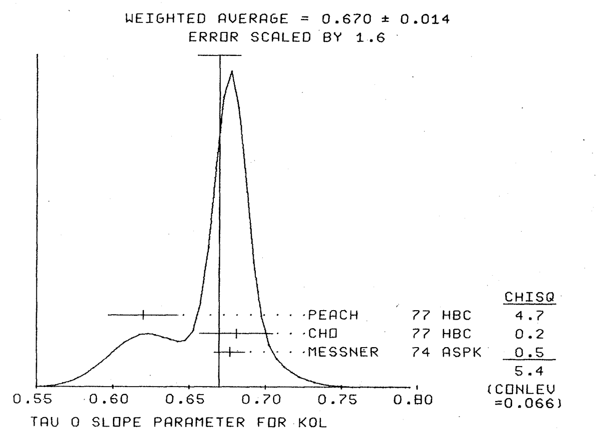


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HTO     QUADRATIC COEFF. H FOR KL --> PI+ PI- PIO MATRIX ELEMENT SQUARED
HTO Q  29K  (-0.011)  (0.018)        ALBROW     70 ASPK                    1/79*
HTO Q 4400   (0.043)  (0.052)        SMITH      70 OSPK                    1/79*
HTO    509K   0.079    0.007         MESSNER    74 ASPK                    3/78
HTO   6499    0.095    0.032         CHO        77 HBC                     3/78
HTO   4709    0.048    0.036         PEACH      77 HBC                     3/78
HTO    SEE NOTES IN SECTION GTO ABOVE.                                     1/79*
HTO           . . . . . . . . .
HTO AVG       0.0786    0.0067  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
HTO STUDENT   0.0787    0.0073  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

KTO     QUADRATIC COEFF. K FOR KL --> PI+ PI- PIO MATRIX ELEMENT SQUARED
KTO    509K   0.0097    0.0018       MESSNER    74 ASPK                    3/78
KTO   6499    0.024     0.010        CHO        77 HBC                     3/78
KTO   4709   -0.C08     0.012        PEACH      77 HBC                     3/78
KTO           . . . . . . . . .
KTO AVG       0.0098    0.0018  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
KTO STUDENT   0.0098    0.0019  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

JTO     LINEAR COEFF. J FOR KL --> PI+ PI- PIO IS LISTED UNDER CP VIOLATION  1/79*
JTO     PARAMETERS IN KOL DECAYS.                                            1/79*

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13 KOL FORM FACTORS

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        RELATED TEXT SECTION VI B.2 AND MINI-REVIEW ON FORM FACTORS
        IN THE CHARGED K SECTION OF THE DATA CARD LISTINGS ABOVE.

        IN THE FORM FACTOR COMMENTS, THE FOLLOWING ABBREVIATIONS ARE USED.
        F+ AND F- ARE FORM FACTORS FOR THE VECTOR MATRIX ELEMENT.
        FS AND FT REFER TO THE SCALAR AND TENSOR TERM.
        FO = (F+) + (F-)*T/(MK**2-MPI**2)
        L+, L- AND LO ARE THE LINEAR EXPANSION COEFFS. OF F+, F- AND FO.
        L+ REFERS TO THE KMU3 VALUE EXCEPT IN THE KE3 SECTIONS.
        DXI/DL IS THE CORRELATION BETWEEN XI(0) AND L+ IN KMU3.
        DLO/DL+ IS THE CORRELATION BETWEEN LO AND L+ IN KMU3.
        T   = MOMENTUM TRANSFER TO THE PI IN UNITS OF MPI**2.
        DP  = DALITZ PLOT ANALYSIS
        PI  = PI SPECTRUM ANALYSIS
        MU  = MU SPECTRUM ANALYSIS
        POL= MU POLARIZATION ANALYSIS
        BR  = KMU3/KE3 BRANCHING RATIO ANALYSIS
        E   = POSITRON OR ELECTRON SPECTRUM ANALYSIS
        RC  = RADIATIVE CORRECTIONS

XIA     XIA = F-/F+ (DETERMINED FROM SPECTRA)  ----------------------------
XIA  L1341    +1.2      (0.8)            CARPENTER 66 OSPK   DP, DXI/DL=-18     1/74
XIA B 3140   (-3.9)     (0.4)            BASILE    70 OSPK   DP, INDEP OF L+    1/74
XIA C  16K   (-0.68)    (0.12)   (0.20)  CHIEN     70 ASPK   DP, DXI/DL=-26     1/74
XIA  A9086    -1.5       0.7             ALBROW    72 ASPK   DP, DXI/DL=-28     1/74
XIA C  16K   (+0.50)    (0.61)           DALLY     72 ASPK   DP, DXI/DL UNKN.   1/74
XIA  P1385    -1.00     (0.45)           PEACH     73 HLBC   DP, DXI/DL=-20     1/74
XIA  D 82K    -0.26      0.21            ALBRECHT  74 WIRE   DP, DXI/DL=-24    11/75
XIA D  82K   (-2.41)    (0.17)           ALBRECHT  74 WIRE   DP, DXI/DL=-9.4   11/75
XIA  E1.6M    -0.11      0.07            DONALDS2  74 SPEC   DP, DXI/DL=-17    11/75
XIA  F 32K    -0.25      0.22            BUCHANAN  75 SPEC   DP, DXI/DL=-5.9    2/76
XIA  L  CARPENTER 66 XI(0) IS FOR L+=0.  DXI/DL IS FROM FIG. 9.                 1/74
XIA B   BASILE 70 IS INCOMPATIBLE WITH ALL OTHER RESULTS.  AUTHORS SUGGEST      1/74
XIA B   THAT EFFICIENCY ESTIMATES MIGHT BE RESPONSIBLE.                         1/74
XIA  A  ALBROW 72 FIT HAS L- FREE, GETS L-=-.030+-.060 OR LAM=+.15+.17-.11.     1/74
XIA C   CHIEN 70 ERRORS ARE STATISTICAL ONLY.  DXI/DL FROM FIG.4.               1/74
XIA  C  DALLY 72 IS A REANALYSIS OF CHIEN 70.  THE DALLY 72 RESULT IS           1/74
XIA  C  NOT COMPATIBLE WITH ASSUMPTION L-=0 SO NOT INCLUDED IN OUR FIT.         2/76
XIA  C  THE NON-ZERO L- VALUE AND THE RELATIVELY LARGE L+ VALUE FOUND BY        1/74
XIA  C  DALLY 72 COME MAINLY FROM A SINGLE LOW T BIN (FIGS.1,2).                1/74
XIA  C  THE (F+,XI) CORRELATION WAS IGNORED.                                    1/74
XIA  C  WE ESTIMATE FROM FIG. 2 THAT FIXING L-=0 WOULD GIVE XI(0)=-1.4+-0.3     1/74
XIA  C  AND WOULD ADD 10 TO CHI SQUARED.  DXI/DL IS NOT GIVEN.                  1/74
XIA  D  ALBRECHT 74 IS CALCULATED BY US FROM LO, L+ AND DLO/DL+.  THEY FIND    11/75
XIA  D  TWO SOLUTICNS.  THE FIRST HAS L+=.046+-.008 IN AGREEMENT WITH KE3.      3/74
XIA  P  PEACH 73 GIVES XIO=-.95+-.45 FOR L+=L-=.025 .  THE ABOVE VALUE IS       1/74
XIA  P  FOR L-=0.  K.PEACH, PRIVATE COMMUNICATION(1974).                        1/74
XIA  E  DONALDSON2 74 GIVES XI=-.11+-.02 NOT INCLUDING SYSTEMATICS.  ABOVE     11/75
XIA  E  ERROR AND DXI/DL WERE CALCULATED BY US FROM LO AND L+ ERRORS (WHICH    11/75
XIA  E  INCLUDE SYSTEMATICS) AND DLO/DL+.                                      11/75
XIA  F  BUCHANAN 75 IS CALCULATED BY US FROM LO, L+ AND DLO/DL+ BECAUSE         2/76
XIA  F  THEIR APPENDIX A VALUE -.20+-22 ASSUMES XI(T) CONSTANT, I.E. L-=L+.     2/76
XIA           . . . . . . . . .
XIA FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN K+- SECTION OF DATA CARDS.

XIB     XIB = F-/F+ (DETERMINED FROM KMU3/KE3)  ---------------------------
XIB     THE KMU3/KE3 BRANCHING RATIO FIXES A RELATIONSHIP BETWEEN XI(0)         1/74
XIB     AND L+.  WE QUOTE THE AUTHORS XI(0) AND ASSOCIATED L+ BUT DO NOT        1/74
XIB     AVERAGE BECAUSE THE L+ VALUES DIFFER.  THE FIT RESULT AND SCALE         1/74
XIB     FACTOR GIVEN IN THE NOTE ON KL3 FORM FACTORS IN THE K+- SECTION OF      2/76
XIB     THE DATA CARDS ARE NOT OBTAINED FROM THESE XIB VALUES.  INSTEAD         2/76
XIB     THEY ARE OBTAINED DIRECTLY FROM THE FITTED KMU3/KE3 RATIO (R10).        2/76
XIB    389    +1.1      1.1              ADAIR     64 HBC    BR, L+=0           1/74
XIB           +0.66     0.9       1.3    LUERS     64 HBC    BR, L+=0           1/74
XIB           +0.2      0.8       1.2    KULYUKINA 68 CC     BR, L+=0           1/74
XIB    569    +0.45     0.28             BEILLIERE 69 HLBC   BR, L+=0           1/74
XIB E 1309   (-0.22)   (0.30)            EVANS     69 HLBC   BR, L+=.02+-.015   1/74
XIB   3548    -0.5      0.5              BASILE    70 OSPK   BR, L+=.02         1/74
XIB   6700     0.5      0.4              BRANDENBU 73 HBC    BR,L+=.019+-.013   1/74
XIB  E1309    -0.C8     0.25             EVANS     73 HLBC   BR, L+=.02         1/74
XIB  E  EVANS 73 REPLACES EVANS 69.                                             1/74
XIB           . . . . . . . . .
XIB FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN K+- SECTION OF DATA CARDS.

XIC     XIC = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)  ------------
XIC     THE MU POLARIZATION IS A MEASURE OF XI(T). NO ASSUMPTIONS ON L+-
XIC     NECESSARY, T (WEIGHTED BY SENSITIVITY TO XIO) SHOULD BE SPECIFIED.
XIC     IN L+,XI(0) PARAMETERIZATION THIS IS XI(0) FOR L+=0.  DXI/DL=XI*T.
XIC      FOR RAD. CORR. TO MUON POLARIZATION IN KMU3, SEE GINSBERG 73.          2/72
XIC T 2608  (-1.2)     (0.5)             AUERBACH  66 OSPK   POLARIZATION       8/67
XIC T  638  (-1.6)     (0.5)             ABRAMS    68 OSPK   POLARIZATION       5/69
XIC  L       -1.81      0.50      0.26   LONGO     69 CNTR   POL. T=3.3         1/74
XIC  S2.2M   -0.385     0.105            SANDWEISS 73 CNTR   POL,DXI/DL=-6      1/74
XIC  H207K   +0.178     0.105            CLARK     77 SPEC   POL,DXI/DL=+.68   11/77
XIC T   T VALUE NOT GIVEN.                                                      1/74
XIC  L  LONGO 69 T=3.3 CALC. FROM DXI/DL=-6.0 (TABLE 1) DIVIDED BY XI=-1.81     1/74
XIC  S  SANDWEISS 73 IS FOR L+=0 AND T=0.                                       1/74
XIC  H  CLARK 77 T=+3.80, DXI/DL=XI(T)*T=.178*3.80=+.68 .                      11/77
XIC           . . . . . . . . .
XIC FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN K+- SECTION OF DATA CARDS.

IXI        IMAGINARY PART OF XI  (TEST OF T REVERSAL)  --------------------
IXI          -0.2       0.6              ABRAMS    68 OSPK   POLARIZATION      10/69
IXI          -0.02      0.08             LONGO     69 CNTR   POL. T=3.3        11/69
IXI   2.2M   -0.060     0.045            SANDWEISS 73 CNTR   POL, T=0           1/74
IXI  S2.2M   -0.085     0.064            SANDWEISS 73 CNTR   POL,T=0           12/79*
IXI  C207K    0.35      0.30             CLARK     77 SPEC   POL, T=0          11/77
IXI           0.012     0.026            SCHMIDT   79 CNTR   POLARIZATICN      12/79*
IXI  S  SANDWEISS 73 VALUE CORRECTED FROM VALUE QUOTED IN THEIR PAPER DUE      12/79*
IXI  S  TO NEW VALUE OF RE(XI). SEE FTNOTE 4 OF SCHMIDT 79.                    12/79*
IXI  C  CLARK 77 VALUE HAS ADDITIONAL XIO DEPENDENCE +0.21*RE(XIO).            11/77
IXI           . . . . . . . . .
IXI AVG      -0.014     0.021   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
IXI STUDENT  -0.013     0.024   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

L+M     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KMU3 DECAY)  ---------
L+M      SEE ALSO THE CORRESPONDING ENTRIES AND NOTES IN SECTION XIA AND LO.
L+M      FOR RAD.COR. OF KMU3 DP SEE GINSBURG 70 AND BECHERRAWY 70.             3/74
L+M C  16K   (0.07)    (0.02)            CHIEN     70 ASPK   DP                 1/74
L+M  A9086    0.085     0.015            ALBROW    72 ASPK   DP                 1/74
L+M C  16K   (0.11)    (0.04)            DALLY     72 ASPK   DP                 1/74
L+M  D 82K    0.046     0.008            ALBRECHT  74 WIRE   DP                11/75
L+M D  82K   (0.076)   (0.004)           ALBRECHT  74 WIRE   DP                11/75
L+M   1.6M    0.030     0.003            DONALDS2  74 SPEC   DP                10/74
L+M    32K    0.046     0.030            BUCHANAN  75 SPEC   DP                 9/75
L+M Z 129K   (0.0337) (0.0033)           DZHORDZHA 77 SPEC   DP                12/79*
L+M    16K    0.028     0.011            HILL      79 STRC   DP                12/79*
L+M C   CHIEN 70 VALUE AND ERROR HAVE BEEN CHANGED FRCM 0.08 +- 0.01 TO         3/71
L+M C   INCLUDE SYSTEMATIC EFFECTS. DALLY 72 IS A REANALYSIS OF CHIEN 70.       3/71
L+M C   SEE NOTE IN SECTION XIA.                                                1/74
L+M  D  ALBRECHT 74 FINDS TWO SOLUTIONS.  THE FIRST AGREES WITH KE3.           11/75
L+M Z   DZHORDZHADZE 77 IS COMBINED ANALYSIS OF THE 82K ALBRECHT 74 EVENTS     12/79*
L+M Z   AND 47K KE3 EVENTS OF BIRULEV 76.                                      12/79*
L+M           . . . . . . . . .
L+M FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN K+- SECTION OF DATA CARDS.

LO      LAMBDA 0 (LINEAR ENERGY DEPENDENCE OF FO IN KMU3 DECAY)  ----------
LO       WHEREVER POSSIBLE, WE HAVE CONVERTED THE ABOVE VALUES OF XI(0) INTO
LO       VALUES OF LO USING THE ASSOCIATED L+M AND DXI/DL.
LO L  1371    +0.08    (0.07)            CARPENTER 66 OSPK   DP,DLO/DL+=-0.54   1/74
LO L          -0.140   (0.043)  (0.022)LONGO       69 CNTR   POL,DLO/DL+=+.49   1/74
LO  B 3140   (-0.333)  (0.034)           BASILE    70 OSPK   DP,DLO/DL+=+1.     1/74
LO A  9086    -0.043    0.052            ALBROW    72 ASPK   DP,DLO/DL+=-1.39   1/74
LO  C  16K   (-0.067)  (0.227)           DALLY     72 ASPK   DP,DLO/DL+ UNKN.   1/74
LO  R 6700   (+0.06)   (0.03)            BRANDENBU 73 HBC    BR,L+=.019+-.013   1/74
LO P  1385    -0.060   (0.038)           PEACH     73 HLBC   DP,DLO/DL+=-0.71   1/74
LO L  2.2M    -0.018   (0.009)           SANDWEISS 73 CNTR   POL,DLO/DL+=+.49   1/74
LO   D 82K    +0.024    0.011            ALBRECHT  74 WIRE   DP,DLO/DL+=-1.06  11/75
LO  D  82K   (-0.130)  (0.014)           ALBRECHT  74 WIRE   DP,DLO/DL+=+0.20  11/75
LO E  1.6M    +C.019    0.004            DONALDS2  74 SPEC   DP,DLO/DL+=-0.47  10/74
LO   F 32K    +0.025    0.019            BUCHANAN  75 SPEC   DP,DLO/DL+=+0.5    2/76
LO L  207K    +0.047   (0.009)           CLARK     77 SPEC   POL,DLO/DL+=1.06  11/77
LO  Z  47K   (+0.0485) (0.0076)          DZHORDZHA 77 SPEC   DP,DLO/DL+=-0.83  12/79*
LO     16K    +0.039    0.010            HILL      79 STRC   DP,DLO/DL+=-0.67  12/79*
LO L    LO VALUE IS FOR L+=0.03  CALCULATED BY US FROM XIO AND DXI/DL .         1/74
LO  B   BASILE 70 LO IS FOR L+=0.  CALCULATED BY US FROM XIA WITH DXI/DL=0.     1/74
LO  B   BASILE 70 IS INCOMPATIBLE WITH ALL OTHER RESULTS.  AUTHORS SUGGEST      1/74
LO  B   THAT EFFICIENCY ESTIMATES MIGHT BE RESPONSIBLE.                         1/74
LO A    ALBROW 72 LO IS CALCULATED BY US FROM XIA,L+ AND DXI/DL.  THEY GIVE     1/74
LO A    LO=-.043+-.039 FOR L-=0.  WE USE OUR LARGER CALCULATED ERROR.           1/74
LO  C   DALLY 72 GIVES FO=1.20+-.35, LO=-.080+-.272, LOPRIME=-.006+-.045,       1/74
LO  C   BUT WITH A DIFFERENT DEFINITION OF LO.  OUR QUOTED LO IS HIS LO/FO.     1/74
LO  C   WE CANNOT CALCULATE TRUE LO ERROR WITHOUT HIS (LO,FO) CORRELATIONS.     1/74
LO  C   SEE ALSO NOTE C IN SECTION XIA.                                         1/74
LO P    PEACH 73 ASSUMES L+=0.025.  CALCULATED BY US FROM XIO AND DXIO/DL+.     1/74
LO  R   FIT FOR LO DOES NOT INCLUDE THIS VALUE BUT INSTEAD INCLUDES THE         2/76
LO  R   KMU3/KE3 RESULT FROM THIS EXPERIMENT.                                   2/76
LO   D  ALBRECHT 74 FINDS TWO SOLUTIONS.  THE FIRST HAS L+=.046+-.008 IN       11/75
LO   D  AGREEMENT WITH KE3.  DLO/DL+ OBTAINED FROM FIG.2C.                     11/75
LO E    DONALDSON2 74 DLO/DL+ OBTAINED FROM FIG. 18.                           11/75
LO   F  BUCHANAN 75 VALUE IS FROM THEIR APPENDIX A AND USES ONLY KMU3 DATA.     2/76
LO   F  DLO/DL+ WAS OBTAINED BY PRIVATE COMMUNICATION, C.BUCHANAN, 1976.        2/76
LO  Z   DZHORDZHADZE 77 IS COMBINED ANALYSIS OF THE 82K ALBRECHT 74 EVENTS     12/79*
LO  Z   AND 47K KE3 EVENTS OF BIRULEV 76.                                      12/79*
LO            . . . . . . . . .
LO  FIT DISCUSSED IN NOTE CN KL3 FORM FACTORS IN K+- SECTION OF DATA CARDS.
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Stable Particles

K_L^0

Data Card Listings

For notation, see key at front of Listings.

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L+E      LAMBDA +   (LINEAR ENERGY DEPENDENCE OF F+ IN KO E3 DECAY)      ------
L+E      FOR RAD.COR. OF KE3 DP SEE GINSBURG 67 AND BECHERRAWY 70.               3/74
L+E    153    +0.07     .06                 LUERS     64 HBC     DP, NO RC
L+E    577    +0.15     .08                 FISHER    65 OSPK    DP, NO RC       8/67
L+E    762    -0.01     .02                 FIRESTONE 67 HBC     DP, NO RC       8/67
L+E    531    +0.01     .015                KADYK     67 HBC     E,PI, NO RC     8/67
L+E    240    +0.08     .10          .08    LOWYS     67 FBC     PI, USES RC     8/67
L+E   1000     0.02    0.013                ARONSON   68 OSPK    PI              5/69
L+E   4800    +0.023   0.012                BASILE    68 OSPK    DP, NO RC       3/68
L+E    42K     0.023   0.005                BISI      71 ASPK    DP, USES RC    12/71
L+E    16K     0.05    0.01                 CHIEN     71 ASPK    DP, NO RC       6/71
L+E   1910     0.022   0.014                NEUHOFER  72 ASPK    PI, USES RC     1/73
L+E   5600     0.045   0.014                ALBROW    73 ASPK    DP, USES RC     9/73
L+E   1871     0.019   0.013                BRANDENBU 73 HBC     PI TRANSV., RC  1/74
L+E   2171     0.040   0.012                WANG      74 OSPK    DP, USES RC     7/74
L+E    25K     0.0270  0.0028               BLUMENTHA 75 SPEC    DP              7/75
L+E    24K     0.044   0.006                BUCHANAN  75 SPEC    DP, USES RC     7/75
L+E    48K     0.032   0.0042               BIRULEV   76 SPEC    DP, USES RC     1/78
L+E   500K     0.0312  0.0025               GJESDAL   76 SPEC    DP, USES RC     1/77
L+E    12K     0.025   0.005                ENGLER    78 HBC     DP, USES RC     7/79*
L+E    18K     0.0348  0.0044               HILL      78 STRC    DP, USES RC     6/78*
L+E             . . . . . . . . .
L+E AVG        0.0301  0.0016  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
L+E STUDENT    0.0300  0.0016  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                       (SEE IDEOGRAM BELOW )
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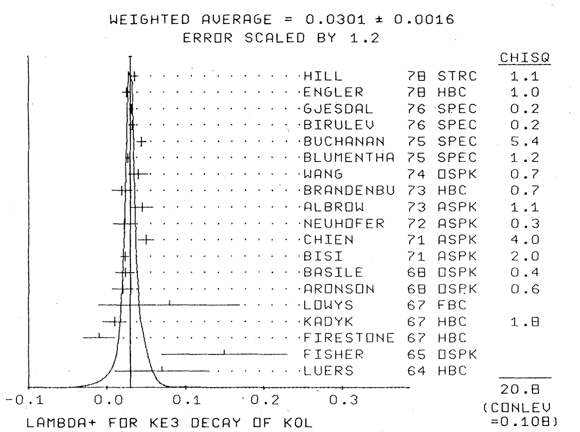


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FS      FS/F+  RATIO OF SCALAR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FS             0.15  OR LESS  CL=.68   KULYUKINA 67 CC                        10/69
FS     5600    0.19  OR LESS  CL=.95   ALBROW    73 ASPK                       9/73
FS      25K    0.04  OR LESS  CL=.68   BLUMENTHA 75 SPEC                       7/75
FS      48K    0.07  OR LESS           BIRULEV   76 SPEC    CL NOT GIVEN       1/78
FS      18K    0.095 OR LESS  CL=.95   HILL      78 STRC                       6/78*

FT      FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FT             1.0   OR LESS  CL=.68   KULYUKINA 67 CC                        10/69
FT     5600    1.0   OR LESS  CL=.95   ALBROW    73 ASPK                       9/73
FT      25K    0.23  OR LESS  CL=.68   BLUMENTHA 75 SPEC                       7/75
FT      48K    0.34  OR LESS           BIRULEV   76 SPEC    CL NOT GIVEN       1/78
FT      18K    0.40  OR LESS  CL=.95   HILL      78 STRC                       6/78*

------ -------- -------- -------- -------- -------- -------- --------

                 13  CP VIOLATION PARAMETERS IN KOL DECAYS

         RELATED TEXT SECTION VI B.3 AND MINI-REVIEW BELOW

-------------------13 CHARGE ASYMMETRY IN TAU DECAYS---------------------

JTO     COEFF OF TERM (S1-S2)/(MPI2) IN MATRIX ELEMENT DEFINED AT BEGINNING
JTO     OF SECTION GTO ABOVE. SEE ALSO MINIREVIEW ON SLOPE PARAMETERS IN
JTO     CHGD K SECTION AND TEXT SEC. VI B.1.  THIS SECTION REPLACES CHARGE
JTO     ASYMMETRY PARAMETER SECTION(A) IN THE 1978 AND EARLIER EDITIONS.
JTO   238K    0.001     0.004        BLANPIED  68                          1/79*
JTO     3M    0.0013    0.0009       SCRIBANO  70                          1/79*
JTO   4400    0.0       0.017        SMITH     70 OSPK                     1/79*
JTO   6499    0.001     0.011        CHO       77                          1/79*
JTO   4709   -0.001     0.003        PEACH     77                          1/79*
JTO            . . . . . . . . .
JTO AVG       0.00110   0.00084  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
JTO STUDENT   0.00111   0.00091  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

-------------------13  CHARGE ASYMMETRY IN LEPTONIC DECAYS (PERCENT)------
TEXT SECTION VI B.3 C

        SUCH ASYMMETRY VIOLATES CP . IT IS RELATED TO REAL(EPSILON).

A1     KOL INTO (MU+PI-NU)-(MU-PI+NU)/(MU+PI-NU)+(MU-PI+NU)     (PERCENT)
A1   D   1M    (0.403)  (0.134)         DORFAN    67 OSPK   DERIVED FROM R16 11/67
A1  D    1M     0.57     0.17           PACIOTTI  69 OSPK                     1/73
A1     7.7M     0.278    0.051          PICCIONI  72 ASPK                     1/73
A1     4.1M     0.60     0.14           MCCARTHY  73 CNTR                     6/73
A1      15M     0.313    0.029          GEWENIG1  74 ASPK                     7/74
A1  D     PACIOTTI 69 IS A REANALYSIS OF DORFAN 67 AND IS CORRECTED FOR       1/73
A1  D     MU+ MU- RANGE DIFFERENCE IN MC CARTHY 72.                           1/73
A1             . . . . . . . . .
A1   AVG        0.319    0.038   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
A1   STUDENT    0.316    0.027   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                 (SEE IDEOGRAM BELOW )

A2     KOL INTO (E+PI-NU)-(E-PI+NU)/(E+PI-NU)+(E-PI+NU)         (PERCENT)
A2   B  10M    (0.224)  (0.036)         BENNETT   67 CNTR                    11/67
A2 B    10M     0.246    0.059          SAAL      69 CNTR                    10/70
A2      10M     0.346    0.033          MARX      70 CNTR                    10/70
A2     600K     0.36     0.18           ASHFORD   72 ASPK                     2/72
A2      40M     0.318    0.038          FITCH     73 ASPK                    12/73
A2      34M     0.341    0.018          GEWENIG1  74 ASPK                     7/74
A2   B SAAL 69 IS A REANALYSIS OF BENNETT 67
A2             . . . . . . . . .
A2   AVG        0.333    0.014   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A2   STUDENT    0.334    0.016   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
```

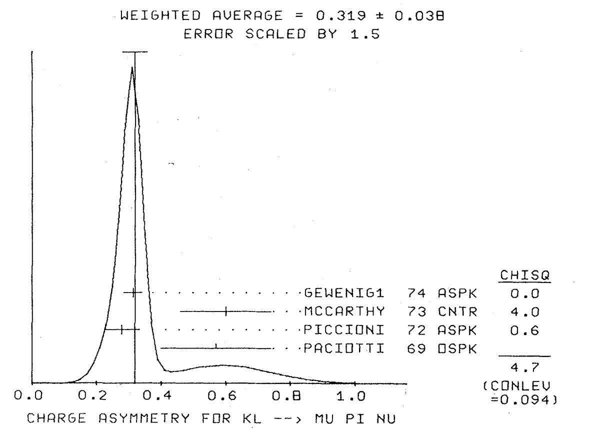


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AL       KOL INTO ((L+)-(L-))/((L+)+(L-))  (COMBINED A1 AND A2) (PERCENT)
AL B    10M     0.246     0.059          SAAL      69 CNTR     KE3           2/71
AL D     1M     0.57      0.17           PACIOTTI  69 OSPK     KMU3          1/73
AL      10M     0.346     0.033          MARX      70 CNTR     KE3           2/71
AL     600K     0.36      0.18           ASHFORD   72 ASPK     KE3           2/72
AL     7.7M     0.278     0.051          PICCIONI  72 ASPK     KMU3          1/73
AL      40M     0.318     0.038          FITCH     73 ASPK     KE3          12/73
AL     4.1M     0.60      0.14           MCCARTHY  73 CNTR     KMU3          6/73
AL      33M     0.333     0.050          WILLIAMS  73 ASPK     KMU3+KE3     12/73
AL      15M     0.313     0.029          GEWENIG1  74 ASPK     KMU3          7/74
AL      34M     0.341     0.018          GEWENIG1  74 ASPK     KE3           7/74
AL       SEE FOOTNOTES IN SECTIONS A1 AND A2 ABOVE.                          1/73
AL              . . . . . . . . .
AL   AVG        0.330     0.012   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AL   STUDENT    0.330     0.013   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

--------------------13  PARAMETERS FOR KOL INTO 2PI DECAY-----------------
TEXT SECTION VI B.3 D

      ETA+- = A(KL TO PI+PI-)/A(KS TO PI+PI-)
      ETA00 = A(KL TO PI0PI0)/A(KS TO PI0PI0)

      THE FITTED VALUES OF ETA+- AND ETA00 GIVEN BELOW ARE THE RESULTS
      OF A FIT TO ETA+-, ETA00 AND ETA00/ETA+- RESULTS.  THE VALUES LISTED
      BELOW WHICH ARE NOT PARENTHESIZED ENTER THE FIT AS SHOWN.  THE
      VALUES WHICH ARE PARENTHESIZED AND BEAR THE FOOTNOTE X DO NOT ENTER
      THE FIT AS SHOWN.  THESE EXPERIMENTS GIVE BRANCHING RATIOS AND ENTER
      THE FIT VIA THE QUANTITY ACTUALLY MEASURED -- BRANCHING RATIOS
      R9, R20 AND R27 (ETA+-) AND R17 AND R19 (ETA00).  THESE BRANCHING
      RATIOS ARE COMBINED WITH CURRENT NORMALIZATIONS AND CURRENT KL AND KS
      MEAN LIVES TO OBTAIN PI PI RATES.  THE ETA+- AND ETA00 VALUES OBTAINED
      FROM THESE RATES ARE ENTERED BELOW WITH THE NAME 'GKL/GKS'.

EOS      (ETA00)**2 = (A(KL TO 2PI0)/A(KS TO 2PI0))**2  (UNITS 10**-6)   ---
EOS X     0  (-2.)       (7.0)          BARTLETT  68 OSPK                     10/69
EOS X    57   (4.9)      (1.2)          BANNER    69 OSPK                      2/72
EOS XR 133  (14.1)       (3.4)          CENCE     69 OSPK                     10/69
EOS XF 180  (13.)        (4.)           GAILLARD  69 OSPK                     10/69
EOS X    29   (4.08)     (0.9)          BARMIN    70 HLBC                     12/70
EOS X    30   (3.61)     (1.9)          BUDAGOV   70 HLBC                     10/70
EOS  C          8.7       3.7           CHOLLET   70 OSPK   CU REG.,4 GAMMAS   2/72
EOS XF 172    (9.9)      (3.4)          FAISSNER  70 OSPK                     12/70
EOS  C  56      7.4       2.0           WOLFF     71 OSPK   CU REG.,4GAMMAS   12/71
EOS XR 150  (14.1)       (3.4)          REY       76 OSPK                      8/76
EOS             5.43      0.84          CHRISTE1  79 ASPK                     12/79*
EOS  X          5.1       1.0           GKL/GKS   78 RVUE BR SCALE FACTOR=1.5  2/80*
EOS X    SEE NOTE ABOVE REGARDING FITTED VALUES OF ETA+- AND ETA00.
EOS  R   CENCE 69 EVENTS ARE INCLUDED IN REY 76.                               1/77
EOS  F   FAISSNER 70 CONTAINS SAME 2PI0 EVENTS AS GAILLARD 69
EOS  C   CHOLLET 70 GIVES ETA00=(1.23+-0.24)*(REGEN AMPL,2GEV/C CU)/10000MB    2/72
EOS  C   WOLFF 71   GIVES ETA00=(1.13+-0.12)*(REGEN AMPL,2GEV/C CU)/10000MB    2/72
EOS  C   WE COMPUTE BOTH ETA00**2 VALUES FOR (REGEN AMPL,2GEV/C CU)=24+-2MB.   2/72
EOS  C   THIS REGEN AMPL RESULTS FROM AVERAGING OVER FAISSNER 69,              2/72
EOS  C   EXTRAPOLATED USING OPTICAL MODEL CALCULTICNS OF BOHM ET AL.           2/72
EOS  C   PL 27B 594 (1968) AND THE DATA OF BALATS 71. (FROM H. FAISSNER,       2/72
EOS  C   PRIVATE COMMUNICATION)                                                2/72
EOS  F   FAISSNER 70 CONTAINS SAME 2PI0 EVENTS AS GAILLARD 69
EOS            . . . . . . . . .
EOS AVG         5.58      0.60    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
EOS STUDENT     5.56      0.66    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
EOS FIT         5.41      0.38   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  2/80*
E00 THIS FIT VALUE CORRESPONDS TO ETA00=2.325+-0.082                            2/80*

E+-     ETA+-  = A(KL TO PI+PI-)/A(KS TO PI+PI-) UNITS 10**-3  ------------
E+- X   45    (1.95)    (0.20)          CHRISTENS 64 OSPK                     2/76
E+- X   54    (1.99)    (0.16)          GALBRAITH 65 OSPK                     2/76
E+- X         (1.92)    (0.13)          BASILE    66 OSPK                     2/76
E+- X         (1.95)    (0.04)          BOTT-BODE 66 OSPK                     2/76
E+- X         (2.00)    (0.09)          DEBOUARD  67 OSPK                     2/76
E+- X         (1.94)    (0.08)          FITCH     67 OSPK                     2/76
E+- AX        (1.95)    (0.03)          GKL/GKS   71 RVUE    EXPTS. BEFORE 71  2/76
E+- A    AVERAGE OF ABOVE EXPERIMENTS.  THESE ARE EXCLUDED FROM THE GKL/GKS,   1/80*
E+- A    AVERAGE, AND FIT VALUES BELOW SINCE THEY DO NOT AGREE WITH MORE       1/80*
E+- A    RECENT PRECISE AND IN PRINCIPLE SUPERIOR EXPERIMENTS.                 1/80*
E+- X 4200    (2.23)    (0.05)          MESSNER   73 ASPK                    11/75
E+-             2.30     0.035          GEWENIG2  74 ASPK                     3/74
E+- X 2703    (2.25)    (0.05)          DEVOE     77 SPEC                    11/77
E+-             2.27     0.12           CHRISTE2  79 ASPK                    12/79*
E+-  X          2.254    0.029          GKL/GKS   78 RVUE    BR EXP. AFTER 71  2/78
E+- X    SEE NOTE ABOVE REGARDING FITTED VALUES OF ETA+- AND ETA00.
E+-            . . . . . . . . .
E+- AVG         2.273    0.022    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
E+- STUDENT     2.272    0.025    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
E+- FIT         2.274    0.022   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*
```

Data Card Listings

For notation, see key at front of Listings.

Stable Particles

K_L^0

```
ER      RATIO OF ETA00 OVER ETA+-
ER      124    1.03     0.07                BANNER1   72 OSPK                    8/72
ER      167    1.00     0.06                HOLDER    72 ASPK                    8/72
ER  C         (1.00)   (0.09)               CHRISTE1  79 ASPK                    2/80*
ER  C    NOT INDEPENDENT OF E+- AND EOS VALUES WHICH ARE INCLUDED IN FIT.        2/80*
ER             . . . . . . . . .
ER  AVG        1.013    0.046    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
ER  STUDENT    1.013    0.049    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
ER  FIT        1.023    0.036   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  2/80*

F+-     PHASE OF ETA +-          (DEGREES)     ------------------------------
F+-      THE DEPENDENCE OF THE PHASE ON THE KOL-KOS MASS DIFFERENCE
F+-      IS GIVEN FOR EACH EXPERIMENT IN THE COMMENTS BELOW, WHERE DM IS
F+-      (MASS DIFF./HBAR) IN UNITS 10**10 SEC-1.  WE HAVE EVALUATED THESE
F+-      MASS DEPENDENCES USING OUR APRIL 1978 VALUE, DM=0.5349+-0.0022
F+-      TO OBTAIN THE VALUES AND AVERAGE QUOTED BELOW. WE ALSO GIVE THE
F+-      REGENERATOR PHASE FR IN THE COMMENTS BELOW.
F+- O        (45.0)   (50.0)                FITCH     65 OSPK    BE REGEN       11/67
F+- O        (30.0)   (45.0)                FIRESTONE 66 HBC                    11/67
F+- O        (70.0)   (21.0)                BOTT-BODE 67 OSPK    C REGEN        11/67
F+- O        (25.0)   (35.0)                MISCHKE   67 OSPK    CU REGEN        7/68
F+- C    CLD EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.              2/76
F+- N        (51.0)   (11.0)                BENNETT2  68 CNTR    CU REG. USES    8/68
F+-  C        34.2     10.0                 BENNETT   69 CNTR    CU REGEN        2/71
F+-  B        45.3     12.0                 BOHM      69 OSPK    VACUUM REGEN    2/71
F+-  F        45.2      7.4                 FAISSNER  69 ASPK    CU REGEN        2/71
F+-  J        40.6      4.2                 JENSEN    70 ASPK    VACUUM REGEN    2/71
F+-  D        37.2     12.0                 BALATS    71 OSPK    CU REGEN        9/71
F+-  P        36.2      6.1                 CARNEGIE  72 ASPK    CU REGEN        1/73
F+-  G        46.5      1.6                 GEWENIG2  74 ASPK    VACUUM REGEN    3/74
F+-  H        45.5      2.8                 CARITHERS 75 SPEC    C REGEN         7/75
F+-           41.7      3.5                 CHRISTE2  79 ASPK                   12/79*
F+-            . . . . . . . . .
F+- AVG       44.6      1.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
F+- STUDENT   44.6      1.4      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
F+- FIT       44.6      1.2     FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*
                   COMMENTS
F+-  N   BENNETT 69 IS A REEVALUATION OF BENNETT2 68.                           11/69
F+-  C   BENNETT 69 USES MEASUREMENT OF (F+-)-(PHIF) OF ALFF-STEINBERGER 66.  2/71
F+-  C   BENNETT 69   F+-=(34.9+-10.0)+ 69*(DM-.545) DEG.  FR=-49.9+-5.4 DEG.  2/71
F+-  B   BOHM 69      F+-=(41.0+-12.0)+479*(DM-.526) DEG.                      2/71
F+-  F   FAISSNER 69 ERROR ENLARGED TO INCLUDE ERROR IN REGENERATOR PHASE.    11/69
F+-  F   FAISSNER 69 F+-=(49.3+-7.4)+205*(DM-.555) DEG.   FR=-42.7+-5.0 DEG.  2/71
F+-  J   JENSEN 70    F+-=(42.4+-4.0)+576*(DM-.538) DEG.                       2/71
F+-  D   BALATS 71    F+-=(39.0+-12.0)+198*(DM-.544) DEG.  FR=-43.0+-4.0 DEG.  9/71
F+-  P   CARNEGIE 72 F+- IS INSENSITIVE TO DM.            FR=-56.2+-5.2 DEG.  1/73
F+-  G   GEWENIG2 74 F+-=(49.4+-1.0)+565*(DM-.540) DEG.                        3/74
F+-  H   CARITHER 75 F+-=(45.5+-2.8)+224*(DM-.5348) DEG.  FR=-40.9+-2.6 DEG. 11/75

FOO     PHASE OF ETA 00     (DEGREES)       ------------------------------------
FOC         FIRST QUADRANT PREFERRED   GOBBI     69 OSPK                      11/69
FOO  C        51.0      30.0                CHOLLET   70 OSPK    CU REG.,4 GAMMAS 10/70
FOO  W  56    38.0      25.0                WOLFF     71 OSPK    CU REG.,4 GAMMAS 12/71
FOC            . . . . . . . . .
FOO AVG       43.3      19.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
FCO STUDENT   43.3      20.7     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
FOO           55.7       5.8                CHRISTE1  79 ASPK                   12/79*
FOO  C   CHOLLET 70 USES REGENERATOR PHASE FR=-46.5+-4.4 DEG.                  1/73
FLO  W   WOLFF 71   USES REGENERATOR PHASE FR=-48.2+-3.5 DEG.                  1/73
FOO            . . . . . . . . .
FCO FIT       54.5       5.3    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*

DF      PHASE DIFFERENCE FOO - F+-      (DEGREES)--------------------------
DF B           7.6      18.0                BARBIELLI 73 ASPK                    7/73
DF  C        (12.6)     (6.2)               CHRISTE1  79 ASPK                    2/80*
DF B     INDEPENDENT OF REGENERATOR MECHANISM,DM,AND LIFETIMES.                  7/73
DF  C    NOT INDEPENDENT OF F+- AND FOO VALUES WHICH ARE INCLUDED IN FIT.        2/80*
DF             . . . . . . . . .
DF  FIT        9.8       5.4    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*
```

Superweak Model Predictions for $|\eta_{00}/\eta_{+-}|$, ϕ_{+-}, and Reε

In terms of the parameters defined in the text, Sec. VI B(d), the superweak model[1] predicts that[2]

$$|\eta_{00}/\eta_{+-}| = 1 \quad ,$$

$$\phi_{+-} = \phi_{00} = \tan^{-1}\left(\frac{2\Delta m \tau_S}{\hbar}\right) \quad ,$$

and

$$\mathrm{Re}\varepsilon = |\eta_{+-}| \left[1 + \left(\frac{2\Delta m \tau_S}{\hbar}\right)^2\right]^{-1/2} \quad .$$

The latter two expressions and the values of the $K_L^0 - K_S^0$ mass difference $\Delta m = (0.5349 \pm 0.0022) \times 10^{10} \hbar$ sec^{-1}, the K_S^0 mean life $\tau_S = (0.8923 \pm 0.0022) \times 10^{-10}$ sec, and the magnitude of the $K_L^0 \to \pi^+\pi^- / K_S^0 \to \pi^+\pi^-$ amplitude ratio $|\eta_{+-}| = (2.274 \pm 0.022) \times 10^{-3}$, all from the current edition, result in the predictions that

$$\phi_{+-} = \phi_{00} = (43.67 \pm 0.14)^\circ$$

and

$$\mathrm{Re}\varepsilon = (1.645 \pm 0.016) \times 10^{-3} \quad .$$

The above predictions can be compared with the experimental values

$$|\eta_{00}/\eta_{+-}| = 1.023 \pm 0.036 \quad ,$$

$$\phi_{+-} = (44.6 \pm 1.2)^\circ \quad ,$$

$$\phi_{00} = (54.5 \pm 5.3)^\circ \quad ,$$

$$\mathrm{Re}\varepsilon = (1.621 \pm 0.088) \times 10^{-3} \quad ,$$

where Reε has been computed using the relation

$$\mathrm{Re}\varepsilon = \frac{\delta}{2}\left(\frac{|1 - x|^2}{1 - |x|^2}\right) \quad ,$$

and our current values of the charge asymmetry parameter for leptonic K_L^0 decay $\delta = (0.330 \pm 0.012)\%$ and the $\Delta S = -\Delta Q$ amplitude (Rex, Imx) = $(0.009 \pm 0.020, -0.004 \pm 0.026)$.

The superweak predictions are in agreement with the data except for the measured value of ϕ_{00}, which is two standard deviations above the prediction. This results primarily from the recent CHRISTENSON1 79 measurement $\phi_{00} = (55.7 \pm 5.8)^\circ$.

References

1. L. Wolfenstein, Phys. Lett. 13, 562 (1964).
2. T. D. Lee and L. Wolfenstein, Phys. Rev. 138B, 1490 (1965).


```
13   X = (DS=-DQ AMPLITUDE)/(DS=+DQ AMPLITUDE)

     RELATED TEXT SECTION VI B.4

REX      REAL PART OF X
REX  C 152    0.06     0.18     0.44  BALDO-CE  65 HLBC   K+ CHARGE EXCHNG 11/67
REX    196    0.035    0.11     0.13  AUBERT    65 HLBC   K+ CHARGE EXCHNG 11/67
REX  F 109   -0.08     0.16     0.28  FRANZINI  65 HBC    PBAR P           11/67
REX    116    0.17     0.16     0.35  FELDMAN   67 OSPK   PI-P TO KO LMBDA 11/67
REX N  335   (0.17)   (0.10)          HILL      67 DBC    K+D YIELDS KOPP  11/67
REX B        (0.03)   (0.03)          BENNETT1  68 CNTR                     7/68
REX    121    0.09     0.07     0.09  JAMES     68 HBC    PBAR P            5/69
REX  B       -0.020    0.025          BENNETT   69 CNTR   CHAR ASYM+ CU RE 10/69
REX    686    0.09     0.14     0.16  LITTENBER 69 OSPK   K+N TO KOP        4/69
REX  N 215    0.12     0.09           CHO       70 DBC    K+D TO KOPP      10/70
REX U  222   (0.04)   (0.07)   (0.08) BURGUN    71 HBC    K+P TO KOPPI+     2/72
REX    252    0.25      .07      .09  WEBBER    71 HBC    K-P TO KBAR N    10/69
REX  U 410    0.03     0.06     0.06  BURGUN    72 HBC    K+P TO KOPPI+     1/73
REX    126    0.26     0.10     0.14  MANN      72 HBC    K-P TO KOBAR N    9/72
REX G  342  (-0.13)   (0.11)          MANTSCH   72 OSPK   KE3  FROM KO LMB  2/72
REX G  100   (0.04)   (0.10)   (0.13) GRAHAM    72 OSPK   KMU3 FROM KO LMB  2/72
REX  G 442   -0.05     0.09           GRAHAM    72 OSPK   PI-P TO KO LMBDA  2/72
REX   1757   -0.008    0.044          FACKLER   73 OSPK   KE3 FROM KO       9/73
REX   1367   -0.03     0.07           HART      73 OSPK   KE3 FROM KO LMB   2/74
REX   1079   -0.070    0.036          MALLARY   73 OSPK   KE3 FROM KO LM +  6/73
REX   4724    0.04     0.03           NIEBERGA  74 ASPK   K+P TO KOPPI+     7/74
REX     79    0.10     0.18     0.19  SMITH     75 WIRE   PI-P TO KO LMBDA  8/76
REX  C  BALDO-CE 65 GIVES X AND THETA.CONVERTED BY US TO REX AND IMX.      11/67
REX  F  FRANZINI 65 GIVES X AND THETA.FOR REX AND IMX SEE SCHMIDT 67.      11/67
REX N   CHO 70 IS ANALYSIS OF UNAMBIGUOUS EVENTS IN NEW DATA AND HILL 67.  10/70
REX  U  BURGUN 72 IS A FINAL RESULT WHICH INCLUDES BURGUN 71.              11/73
REX  B  BENNETT 69 IS A REANALYSIS OF BENNETT1 68.                         10/69
REX G   SECOND GRAHAM 72 VALUE IS FIRST GRAHAM 72 VALUE COMBINED WITH       2/72
REX G   MANTSCH 72.                                                         2/72
REX          . . . . . . . . .
REX AVG        0.009    0.020  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
REX STUDENT    0.008    0.017  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                       (SEE IDEOGRAM BELOW )
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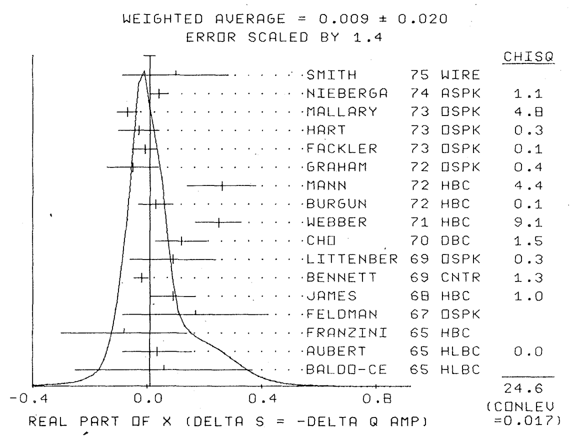
Stable Particles

K_L^0

Data Card Listings

For notation, see key at front of Listings.



IMX IMAGINARY PART OF X (ASSUMES M(KL)-M(KS) POSITIVE -- SEE S13D)

IMX	C	152	-0.44	0.32	0.19	BALDO-CE	65	HLBC	K+ CHARGE EXCHNG	3/68
IMX		196	-0.21	0.11	0.15	AUBERT	65	HLBC	K+ CHARGE EXCHNG	3/68
IMX	F	109	+0.24	0.40	0.30	FRANZINI	65	HBC	PBAR P	3/68
IMX		116	0.0	0.25		FELDMAN	67	OSPK	PI-P TO KO LMBDA	11/67
IMX	N	335	(-0.20)	(0.10)		HILL	67	DBC	K+D YIELDS KOPP	11/67
IMX		121	+0.22	0.37	0.29	JAMES	68	HBC	PBAR P	5/69
IMX		686	-0.11	0.10	0.11	LITTENBER	69	OSPK	K+N TO KOP	4/69
IMX	N	215	-0.08	0.07		CHO	70	DBC	K+D TO KOPP	10/70
IMX	U	222	(0.12)	(0.08)	(0.09)	BURGUN	71	HBC	K+P TO KOPPI+	2/72
IMX		252	0.0	.08		WEBBER	71	HBC	K-P TO KBAR N	10/69
IMX	U	410	0.07	0.06	0.07	BURGUN	72	HBC	K+P TO KOPPI+	1/73
IMX		126	0.21	0.15	0.12	MANN	72	HBC	K-P TO KOBAR N	9/72
IMX	G	342	(-0.04)	(0.16)		MANTSCH	72	OSPK	KE3 FROM KO LMB	2/72
IMX	G	100	(0.12)	(0.17)	(0.16)	GRAHAM	72	OSPK	KMU3 FROM KO LMB	2/72
IMX	G	442	0.05	0.13		GRAHAM	72	OSPK	PI-P TO KO LMBDA	2/72
IMX		1757	-0.017	0.060		FACKLER	73	OSPK	KE3 FROM KO	9/73
IMX		1367	0.09	0.07		HART	73	OSPK	KE3 FROM KO LMB	2/74
IMX		1079	0.107	0.092	0.074	MALLARY	73	OSPK	KE3 FROM KO LM +	6/73
IMX		4724	-0.06	0.05		NIEBERGA	74	ASPK	K+P TO KOPPI+	7/74
IMX		79	-0.10	0.16	0.19	SMITH	75	WIRE	PI-P TO KO LMBDA	8/76

IMX C BALDO-CE 65 GIVES X AND THETA.CONVERTED BY US TO REX AND IMX. 11/67
IMX F FRANZINI 65 GIVES X AND THETA.FOR REX AND IMX SEE SCHMIDT 67. 11/67
IMX N FTNOTE 10 OF HILL 67 SHOULD READ +0.58, NOT -0.58 (PRIV.COMM.). 3/68
IMX N CHO 70 IS ANALYSIS OF UNAMBIGUOUS EVENTS IN NEW DATA AND HILL 67. 10/70
IMX U BURGUN 72 IS A FINAL RESULT WHICH INCLUDES BURGUN 71. 11/73
IMX G SECOND GRAHAM 72 VALUE IS FIRST GRAHAM 72 VALUE COMBINED WITH 2/72
IMX G MANTSCH 72. 2/72
IMX . . . .
IMX AVG -0.004 0.026 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
IMX STUDENT -0.005 0.027 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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REFERENCES FOR KOL

BARDON 58 ANP 5 156 M BARDON,K LANDE,L LEDERMAN (COLUMBIA+BNL)
CRAWFORD 59 PRL 2 361 CRAWFORD,CRESTI,DOUGLASS,GOOD + (LRL)
ASTIER 61 AIX CONF 1 227 ASTIER,BLASKOVIC,RIVET,SIAUD + (EPOL)
FITCH 61 NC 22 1160 V FITCH,P PIROUE,R PERKINS (PRINCETON)
GOOD 61 PR 124 1223 GOOD,MATSEN,MULLER,PICCIONI,POWELL + (LRL)
NEAGU 61 PRL 6 552 NEAGU,OKONOV,PETROV,ROSANOVA,RUSAKOV (JINR)
ALSO 61 JETP 13 1138 NYAGU,OKONOV,PETROV,ROZANOVA,RUSAKOV (JINR)

CAMERINI 62 PR 128 362 CAMERINI,FRY,GAIDOS,BIRGE,ELY + (WISC+LRL)
DARMON 62 PL 3 57 J DARMON,A ROUSSET,J SIX (EPOL)

ADAIR 64 PL 12 67 R K ADAIR,L B LEIPUNER (YALE+BNL)
ALEKSANY 64 DUBNA 2 102 ALEKSANYAN,ALIKHANYAN,VARTAZARYAN+ (EREVAN)
ALSO 64 JETP 19 1019 ALEKSANYAN+ (LEBEDEV+MOS ENG PHYS+EREVAN)
ANIKINA 64 JETP 19 42 ANIKINA,ZHURAVLEVA+ (GEORG ACAD SCI+ DUBNA)
CHRISTEN 64 PRL 13 138 CHRISTENSON,CRONIN,FITCH,TURLAY (PRINCETON)
FUJII 64 DUBNA 2 146 FUJII,JOVANOVICH,TURKOT+ (BNL,MARYLAND,MIT)
LUERS 64 PR 133 B 1276 LUERS,MITTRA,WILLIS,YAMAMOTO (BNL)

ANIKINA 65 JINR P 2488 ANIKINA,VARDENGA,ZHURAVLEVA,KOTLYA+ (DUBNA)
ANDERSON 65 PRL 14 475 ANDERSON,CRAWFORD,GOLDEN,STERN + (LRL+WISC)
ASTBURY1 65 PL 16 80 ASTBURY,FINOCCHIARO,BEUSCH + (CERN+ZURICH)
ALSO 65 HELV.PH.AC.39 523 M PEPIN
ASTBURY2 65 PL 18 175 ASTBURY,MICHELINI,BEUSCH + (CERN+ZURICH)
ASTBURY3 65 PL 18 178 ASTBURY,MICHELINI,BEUSCH + (CERN+ZURICH)

AUBERT 65 PL 17 59 AUBERT,BEHR,CANAVAN,CHOUNET+ (EPOL+ORSAY)
ALSO 67 LOWYS
BALDO-CE 65 NC 38 684 BALDO-CEOLIN,CALIMANI,CIAMPOLILLO + (PADO)
CHRISTEN 65 PR 140 B 74 CHRISTENSON,CRONIN,FITCH,TURLAY (PRINCETON)
FISHER 65 ANL 7130 83 FISHER,ABASHIAN,ABRAMS,CARPENTER+ (ILL)
FITCH 65 PRL 15 73 FITCH,ROTH,RUSS,VERNON (PRINCETON)

FRANZINI 65 PR 140 B 127 FRANZINI,KIRSCH,PLANO + (COLUMBIA+RUTGERS)
GALBRAIT 65 PRL 14 383 GALBRAITH,MANNING,JONES + (AERE+BRIS+RHEL)
GUIDONI 65 ARGONNE CONF 49 +BARNES,FOELSCHE,FERBEL,FIRESTO+ (BNL+YALE)
HOPKINS 65 ARGONNE CONF 67 H W K HOPKINS,BACON,EISLER (VAND+RUTGERS)
VISHNEVS 65 PL 18 339 VISHNEVSKY,GALANINA,SEMENOV + (ITEP)

ALFF-STE 66 PL 21 595 ALFF-STEINBERGER,HEUER,RUBBIA + (CERN)
ANIKINA 66 SJNP 2 339 ANIKINA, VARDENGA, ZHURAVLEVA+ (JINR)
AUERBACH 66 PRL 17 980 AUERBACH,MANN,MCFARLANE,SCIULLI (PENN)
AUERBACH 66 PR 149 1052 AUERBACH,DOBBS,LANDE,MANN,SCIULLI+ (PENN)
ALSO 65 PRL 14 192 +LANDE,MANN,SCIULLI,UTO,WHITE,YOUNG (PENN)
BALDO-CE 66 NC 45A 733 BALDO-CEOLIN,CALIMANI,CIAMPOLILLO+ (PADUA)
BASILE 66 BALATON CONF BASILE,CRONIN,THEVENET + (SACLAY)

BEHR 66 PL 22 540 +BRISSON,BALDO-CEOLIN,AUBERT+ (PADO,EPOL)
BELLOTTI 66 NC 45A 737 BELLOTTI,PULLIA,BALDO-CEOLIN+ (MILAN,PADUA)
BOTT-BOD 66 PL 23 277 BOTT-BODENHAUSEN,DE BOUARD,CASSEL+ (CERN)
CAMERINI 66 PR 150 1148 CAMERINI,CLINE,ENGLISH,FISCHBEIN+WISCONSIN
CANTER 66 PRL 17 942 +CHO,ENGLER,FISK,HILL + (CARNEGIE+BNL)
CARPENTE 66 PR 142 871 CARPENTER,ABASHAN,ABRAMS,FISHER (ILLINOIS)
CHANG 66 PL 23 702 CHANG,BASSANO,KIKUCHI,DODD+ (SYRACUSE,BNL)

CRIEGEE 66 PRL 17 150 +FOX,FRAUENFELDER,HANSON,MOSCAT+ (ILLINOIS)
FIRESTON 66 PRL 16 556 FIRESTONE,KIM,LACH,SANDWEISS+ (YALE,BNL)
FIRESTON 66 PRL 17 116 FIRESTONE,KIM,LACH,SANDWEISS+ (YALE,BNL)
FUJII 66 PRL 13 253 FUJII,JOVANOVICH,TURKOT,ZORN (BNL+MARYLAND)
FUJII 66 IS THE CORRECTED VALUE GIVEN BY JOVANOVICH+ 66
HAWKINS 66 PL 21 238 C J B HAWKINS (YALE)
ALSO 67 PR 156 1444 C J B HAWKINS (YALE)

JOVANOVI 66 PRL 17 1075 JOVANOVICH,FUJII,TURKOT,ZORN +(BNL+UMD+MIT)
KULYUKIN 66 BERKELEY 2B KULYUKINA,MESTVIRISHVILI,NEAGU,PETR+ (JINR)
MEISNER1 66 PRL 16 278 G W MEISNER,B B CRAWFORD,F CRAWFORD (LRL)
MEISNER2 66 PRL 17 492 G MEISNER,B CRAWFORD,F CRAWFORD (LRL)
NEFKENS 66 PL 19 706 NEFKENS,ABASHIAN,ABRAMS,CARPENTER+ (ILL)
VERHEY 66 PRL 17 669 VERHEY,NEFKENS,ABASHIAN+ (ILL)

BENNETT 67 PRL 19 993 BENNETT,NYGREN,SAAL,STEINBERGER +(COLUMBIA)
BOTT-BOD 67 PL 24B 194 BOTT-BODENHAUSEN,DEBOUARD,CASSEL + (CERN)
BOTT-BOD 67 PL 24B 438 BOTT-BODENHAUSEN,DEBOUARD,DEKKERS+ (CERN)
ALSO 66 PL 20 212 BOTT-BODENHAUSEN,DEBOUARD,CASSEL+ (CERN)
ALSO 66 PL 23 277 BOTT-BODENHAUSEN,DEBOUARD,CASSEL+ (CERN)
CANTER 67 THESIS J.M. CANTER (CARNEGIE)

CRONIN 1 67 PRL 18 25 +KUNZ,RISK,WHEELER (PRINCETON)
CRONIN 2 67 PRINC CONF(11/67) +KUNZ,RISK,WHEELER (PRINCETON)
DEBOUARD 67 NC 52A 662 DEBOUARD,DEKKERS,JORDAN,MERMOD + (CERN)
ALSO 65 PL 15 58 DE BOUARD,DEKKERS,SCHARFF+ (CERN+ORSA+MPIM)
DEVLIN 67 PRL 18 54 DEVLIN,SOLOMON,SHEPARD,BEALL+ (PRIN+UMD)
ALSO 68 PR 169 1045 SAYER,BEALL,DEVLIN,SHEPHARD+ (UMD+PPA+PRIN)

DORFAN 67 PRL 19 987 DORFAN,ENSTROM,RAYMOND,SCHWARTZ +(SLAC+LRL)
FELDMAN 67 PR 155 1611 FELDMAN,FRANKEL,HIGHLAND,SLOAN (PENN)
FIRESTON 67 PRL 18 176 FIRESTONE,KIM,LACH,SANDWEISS,+ (YALE,BNL)
FITCH 67 PR 164 1711 FITCH,ROTH,RUSS,VERNON (PRINCETON)
HAWKINS 67 PR 156 1444 C J B HAWKINS (YALE)
HILL 67 PRL 19 668 HILL,LUERS,ROBINSON,CANTER+ (BNL,CARNEGIE)

HOPKINS 67 PRL 19 185 HOPKINS,BACON,EISLER (BNL)
KADYK 67 PRL 19 597 KADYK,CHAN,DRIJARD,OREN,SHELDON (LRL)
KULYUKIN 67 PREPRINT KULYUKINA+MESTVIRISHVILI+NEAGU + (JINR)
LOWYS 67 PL 24B 75 LOWYS,AUBERT,CHOUNET,PASCAUD+ (EPOL,ORSA)
MISCHKE 67 PRL 18 138 MISCHKE,ABASHIAN,ABRAMS+ (ILLINOIS)
NEFKENS 67 PR 157 1233 +ABASHIAN,ABRAMS,CARPENTER,FISHER+ (ILL)
TODOROFF 67 THESIS JOHN A TODOROFF (ILLINOIS)

ABRAMS 68 PR 176 1603 +ABASHIAN,MISCHKE,NEFKENS,SMITH+ (ILLINOIS)
ARNOLD 68 PL 28B 56 ARNOLD,BUDAGOV,CUNDY,AUBERT+ (CERN+ORSAY)
ARONSON 68 PRL 20 287 S.H.ARONSON, K.W.CHEN (PRINCETON)
ALSO 69 PR 175 1708 S H ARONSON, K W CHEN (PRINCETON)
BALATZ 68 PL 26B 320 BALATZ,BEREZIN,VISHNEVSKY,GALANINA+ (ITEP)
BARTLETT 68 PRL 21 558 BARTLETT,CARNEGIE,FITCH+ (PRINCETON)

BASILE 68 PL 26B 542 BASILE,CRONIN,THEVENET,TURLAY+ (SACLAY)
BASILE2 68 PL 28B 58 +CRONIN,THEVENET,TURLAY,ZYLBERAJCH+(SACLAY)
BENNETT1 68 PL 27B 244 BENNETT,NYGREN,STEINBERGER+ (COLUMBIA+CERN)
BENNETT2 68 PL 27B 248 BENNETT,NYGREN,STEINBERGER+ (COLUMBIA+CERN)
BLANPIED 68 PRL 21 1650 BLANPIED,LEVIT,ENGELS+ (CASE+HARV+MCGI)
BUDAGOV 68 NC 57A 182 BUDAGOV,BURMEISTER,CUNDY+ (CERN,ORSA,IPNP)
ALSO 68 PL 28B 215 +CUNDY,MYATT,NEZRICK+ (CERN,ORSA,EPOL)

CARNEGIE 68 PRINC TR44 THESIS R.K.CARNEGIE (PRINCETON)
JAMES 68 NP B8 365 F JAMES, H BRIAND (IPNP,CERN)
ALSO 68 PRL 21 257 HELLAND,LONGO,YOUNG (UCLA,MICH)
KULYUKIN 68 JETP 26 20 KULYUKINA,MESTVIRISHVILI,NEAGU+ (JINR)
KUNZ 68 THESIS (PU 46) P F KUNZ (PRINCETON)
MELHOP 68 PR 172 1613 MELHOP MURTY BOWLES,BURNETT+ (LA JOLLA)
THATCHER 68 PR 174 1674 THATCHER,ABASHIAN,ABRAMS,CARPENTER + (ILL)

BANNER 69 PR 188 2033 +CRONIN,LIU,PILCHER (PRINCETON)
ALSO 68 PRL 21 1103 BANNER,CRONIN,LIU,PILCHER (PRINCETON)
ALSO 68 PRL 21 1107 BANNER CRONIN,LIU,PILCHER (PRINCETON)
BEILLIER 69 PL 30B 202 BEILLIERE,BOUTANG,LIMON (EPOL)
BENNETT 69 PL 29B 317 +NYGREN,SAAL,STEINBERGER+ (COLU,BNL)
BOHM 69 NP B9 605 +DARRIULAT,GROSSO,KAFTANOV+ (CERN)
ALSO 68 PL 27B 321 BOHM,DARRIULAT,GROSSO,KAFTANOV (CERN)

BOTT-BOD 69 CERN 69-7 329 BOTT-BODENHAUSEN,DE BOUARD,CASSEL+ (CERN)
CENCE 69 PRL 22 1210 CENCE,JONES,PETERSON,STENGER+ (HAWAII,LRL)
EVANS 69 PRL 23 427 EVANS,GOLDEN,MUIR,PEACH+ (EDINBURGH,CERN)
FAISSNER 69 PL 30B 204 +FOETH,STAUDE,TITTEL+ (AACH,CERN,TORI)
FOETH 69 PL 30B 282 +HOLDER,RADERMACHER + (AACHEN,CERN,TORINO)

GAILLARD 69 NC 59A 453 +GALBRAITH,HUSSRI,JANE+ (CERN,RHEL,AACHEN)
ALSO 67 PRL 18 20 +KRIENEN,GALBRAITH,HUSSRI+ (CERN+RHEL+AACH)
GOBBI 69 PRL 22 685 +GREEN,HAKEL,MOFFETT,ROSEN,GOZ+ (ROCH+RUTG)
LITTENBE 69 PRL 22 654 LITTENBERG,FIELD,PICCIONI,MEHLHOP+ (UCSD)
LONGO 69 PR 181 1808 M J LONGO,K K YOUNG,J A HELLAND (MICH,UCLA)
PACIOTTI 69 THESIS,UCRL 19446 M A PACIOTTI (LRL)
SAAL 69 THESIS H J SAAL (COLUMBIA)

ALBROW 70 PL 33B 516 +ASTON,BARBER,BIRD,ELLISON + (MCHS+DARE)
ARONSON 70 PRL 25 1057 +EHRLICH,HOFER,JENSEN+ (EFI,ILLC,SLAC)
BARMIN 70 PL 33B 377 +BARYLON,BORISOV,BYSHEVA+ (ITEP,JINR)
BASILE 70 PR D2 78 +CRONIN,THEVENT,TURLAY,ZYLBERAJCH + (SACL)
BUCHANAN 70 PL 33B 623 +DRICKEY,RUDNICK,SHEPARD+ (SLAC,JHU,UCLA)
ALSO PRIVATE COMMUNICATION, B. COX, FEB. 71

BUDAGOV 70 PR D2 815 +CUNDY,MYATT,NEZRICK+ (CERN, ORSA,EPOL)
ALSO 68 PL 28B 215 +CUNDY,MYATT,NEZRICK+ (CERN,ORSA,EPOL)
CHIEN 70 PL 33B 627 C-Y.CHIEN,COX,ETTLINGER + (JHU+SLAC+UCLA)
ALSO PRIVATE COMMUNICATION, B. COX, FEB. 71.
CHO 70 PR D1 3031 +DRALLE,CANTER,ENGLER,FISK+ (CARN,BNL,CASE)
ALSO 67 PRL 19 668 HILL,LUERS,ROBINSON,SAKITT + (BNL,CARN)

CHOLLET 70 PL 31B 658 +GAILLARD,JANE,RATCLIFFE,REPELLIN + (CERN)
CULLEN 70 PL 32B 523 +DARRIULAT,DEUTSCH,FOETH + (AACH,CERN,TORI)
DARRIULA 70 PL 33B 249 +FERRERO,GROSSO,HOLDER + (AACH,CERN,TORI)
FAISSNER 70 NC 70A 57 +REITHLER,THOME,GAILLARD+ (AACH,CERN,RHEL)
JENSEN 70 THESIS D.A. JENSEN (EFI)
ALSO 69 PRL 23 615 JENSEN,ARONSON,EHRLICH,FRYBERGER+ (EFI,ILL)

MARX 70 PL 32B 219 +NYGREN,PEOPLES,STEINBERGE+(COLU,HARV,CERN)
ALSO 70 THESIS,NEVIS 179 JAY MARX (COLUMBIA)
SCRIBANO 70 PL 32B 224 +MANNELLI,PIERAZZINI,MARX+ (PISA,COLU,HARV)
SMITH 70 PL 32B 133 +WANG,WHATLEY,ZORN,HORNBOSTEL (UMD,BNL)
WEBBER 70 PR D1 1967 +SOLMITZ,CRAWFORD,ALSTON-GARNJOST (LRL)
ALSO 69 UCRL 19226 THESIS B R WEBBER (LRL)

BALATS 71 SJNP 13 53 +BEREZIN,VISHNEVSKII,GALANINA+ (ITEP)
BARMIN 71 PL 35B 604 +BARYLOV,VESELOVSKY,DAVIDENKO+ (ITEP)
BISI 71 PL 36B 533 +DARRIULAT,FERRERO,RUBBIA+ (AACH,CERN,TORI)
BURGUN 71 LNC 2 1169 +LESQUOY,MULLER,PAULI+ (SACL+CERN+OSLO)
CARNEGIE 71 PR D4 1 +CESTER,FITCH,STROVINK,SULAK (PRIN)
CHAN 71 LBL-350 THESIS J.HIONG-SING CHAN (LBL)

CHIEN 71 PL 35B 261 +COX,ETTLINGER,RESVANIS+ (JHU,SLAC,UCLA)
ALSO 72 CALLY

Data Card Listings

For notation, see key at front of Listings.

Stable Particles

K^0_L, $D^{\pm}$


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CHO       71 PR D3 1557           +DRALLE,CANTER,ENGLER,FISK+ (CARN,BNL,CASE)
CLARK     71 PRL 26 1667          +ELIOFF,FIELD,FRISCH,JOHNSON,KERTH+    (LRL)
    ALSO 70 UCRL 19709-THESIS ROLLAND JOHNSON                           (LRL)
    ALSO 71 UCRL 20264-THESIS HENRY FRISCH                              (LRL)
    ALSO 74 SLAC-PUB-1498     R.C.FIELD                                (SLAC)

ENSTROM   71 PR D4 2629           +AKAVIA,COOMBES,DORFAN+        (SLAC,STAN)
    ALSO 70 THESIS (SLAC 125) J E ENSTROM                         (STANFORD)
HILL      71 PR D4 7              +SAKITT,SKJEGGESTAD,CANTER+ (BNL,CARN,CASE)
JAMES     71 PL 35B 265           +MONTANET,PAUL,PAULI+      (CERN+SACL+OSLO)
MEISNER   71 PR D3 59             +MANN,HERTZBACH,KOFLER +    (MASA+BNL+YALE)
PEACH     71 PL 35B 351           +EVANS,MUIR,BUDAGOV,HOPKINS+     (EDIN,CERN)

REPELLIN  71 PL 36B 603           +WOLFF,CHOLLET,GAILLARD,JANE+    (ORSA,CERN)
WEBBER    71 PR D3 64             +SOLMITZ,CRAWFORD,ALSTON-GARNJOST      (LRL)
    ALSO 68 PRL 21 498        WEBBER,SOLMITZ,CRAWFORD,ALSTONGARNJOST(LRL)
    ALSO 69 UCRL 19266-THESIS B R WEBBER                                (LRL)
WOLFF     71 PL 36B 517           +CHOLLET,REPELLIN,GAILLARD+      (ORSA,CERN)

ALBROW    72 NP B44 1             +ASTON,BARBER,BIRD,ELLISON+      (MCHS+DARE)
ASHFORD   72 PL 38B 47            +BROWN,MASEK,MAUNG,MILLER,RUDERMAN+  (UCSD)
BANNER1   72 PRL 28 1597          +CRONIN,HOFFMAN,KNAPP,SHOCHET   (PRINCETON)
BANNER2   72 PRL 29 237           +CRONIN,HOFFMAN,KNAPP,SHOCHET   (PRINCETON)
BARMIN1   72 SJNP 15 636          +DAVIDENKO,DEMIDOV,DOLGOLENKO+        (ITEP)
BARMIN2   72 SJNP 15 638          +BARYLOV,DAVIDENKO,DEMIDOV+           (ITEP)
BURGUN    72 NP B50 194           +LESQUOY,MULLER,PAULI,+    (SACL+CERN+OSLO)
CARNEGIE  72 PR D6 2335           +CESTER,FITCH,STROVINK,SULAK    (PRINCETON)

DALLY     72 PL 41B 647           +INNOCENTI,SEPPI,CHIEN,COX+ (SLAC+JHU+UCLA)
    ALSO 70 CHIEN
    ALSC 71 CHIEN
GRAHAM    72 NC 9A 166            +ABASHIAN,JONES,MANTSCH,ORR+      (ILL+NEAS)
HOLDER    72 PL 40B 141           +RADERMACHER,STAUDE+       (AACH+CERN+TCRI)
JAMES     72 NP B49 1             +MONTANET,PAUL,SAETRE+     (CERN+SACL+OSLO)
KRENZ     72 LNC 4 213            +HOPKINS,EVANS,MUIR,PEACH  (AACH+CERN+EDIN)

MANN      72 PR D6 137            +KOFLER,MEISNER,HERTZBACH+  (MASA+BNL+YALE)
MANTSCH   72 NC 9A 160            +ABASHIAN,GRAHAM,JONES,ORR+       (ILL+NEAS)
METCALF   72 PL 40B 703           +NEUHOFER,NIEBERGALL+       (CERN+IPN+WIEN)
NEUHOFER  72 PL 41B 642           +NIEBERGALL,REGLER,STIER+  (CERN+ORSA+VIEN)
PICCIONI  72 PRL 29 1412          +COOMBES,DONALDSON,DORFAN,FRYBERGER+ (SLAC)
    ALSO 74 PR D9 2939        PICCIONI,DONALDSON +        (SLAC+UCSC+COLO)
VOSBURGH  72 PR D6 1834           +DEVLIN,ESTERLING,GOZ,BRYMAN +  (RUTG,MASA)
    ALSC 71 PRL 26 866        VOSBURGH,DEVLIN,ESTERLING,GOZ + (RUTG,MASA)

ALBROW    73 NP B58 22            +ASTON,BARBER,BIRD,ELLISON+      (MCHS+DARE)
ALEXANDE  73 NP B65 301           ALEXANDER,BENARY,BOROWITZ,LANDE+(TELA+HEID)
ANIKINA   73  P1-7539 COM.JINR    +BALASHOV,BANNIK +                    (JINR)
BARBIELL  73 PL 43B 529           BARBIELLINI,DARRIULAT,FAINBERG+       (CERN)
BRANDENB  73 PR D8 1978           BRANDENBURG,JOHNSON,LEITH,LOOS+       (SLAC)
CARITHER  73 PRL 31 1025          CARITHERS,NYGREN,GORDON+    (COLU+BNL+CERN)
    ALSO 73 PRL 30 1336       CARITHERS,MODIS,NYGREN,PUN+ (COLU+CERN+NYU)
EVANS     73 PR D7 36             +MUIR,PEACH,BUDAGOV+        (EDINBURGH+CERN)
    ALSC 69 PRL 23 427        EVANS,GOLDEN,MUIR,PEACH+    (EDINBURGH+CERN)

FACKLER   73 PRL 31 847           +FRISCH,MARTIN,SMOOT,SOMPAYRAC         (MIT)
FITCH     73 PRL 31 1524          +HEPP,JENSEN,STROVINK,WEBB      (PRINCETON)
    ALSO 72 COO-3072-13       R.C.WEBB (THESIS)                   (PRINCETON)
HART      73 NP B66 317           +HUTTON,FIELD,SHARP,BLACKMORE+  (CAVE+RHEL)
MALLARY   73 PR D7 1953           +BINNIE,GALLIVAN,GOMEZ,PECK,SCIULLI + (CIT)
    ALSO 70 PRL 25 1214       SCIULLI,GALLIVAN,BINNIE,GOMEZ +           (CIT)

MCCARTHY  73 PR D7 687            +BREWER,BUDNITZ,ENTIS,GRAVEN,MILLER+  (LBL)
    ALSO 72 PL 42B 291        MCCARTHY,BREWER,BUDNITZ,ENTIS,GRAVEN+ (LBL)
    ALSO 71 THESIS LBL-550    R.L.MCCARTHY                              (LBL)
MESSNER   73 PRL 30 876           +MORSE,NAUENBERG,HITLIN +  (COLO+SLAC+UCSC)
PEACH     73 PL 43B 441           +EVANS,MUIR,HOPKINS,KRENZ  (EDIN+CERN+AACH)
SANDWEIS  73 PRL 30 1302          +SUNDERLAND,TURNER,WILLIS,KELLER (YALE+ANL)
WILLIAMS  73 PRL 31 1521          +LARSEN,LEIPUNER,SAPP,SESSOMS+   (BNL+YALE)

ALBRECHT  74 PL 48B 393           DUBNA+BERLIN+BUDAPEST+PRAGUE+SERPUKH+SOFIA
BISI      74 PL 50B 504           BISI,FERRERO                          (TORI)
BOBISUT   74 LNC 11 646           +HUZITA,MATTIOLI,PUGLIERIN            (PADO)
DONALDS1  74 PRL 33 554           DONALDSON,HITLIN,KENNELLY,KIRKBY +    (SLAC)
    ALSO 74 DONALDSON 3
    ALSO 76 DONALDSON
DONALDS2  74 PR D9 2960           DONALDSON,FRYBERGER,HITLIN,LIU+ (SLAC+UCSC)
    ALSO 73 PRL 31 337        DONALDSON,FRYBERGER,HITLIN,LIU+ (SLAC+UCSC)
DONALDS3  74 SLAC 184-THESIS      GREGORY J. DONALDSON                  (SLAC)
    ALSO 76 DONALDSON

GEWENIG1  74 PL 48B 483           GEWENIGER,GJESDAL,KAMAE,PRESSER+(CERN+HEID)
    ALSO 74 CERN INT. REPT.   VERA LUTH (THESIS-INT. REPT. 74-4)     (HEID)
GEWENIG2  74 PL 48B 487           GEWENIGER,GJESDAL,PRESSER +      (CERN+HEID)
    ALSO 74 PL 52B 119        GJESDAL,PRESSER,STEFFEN +        (CERN+HEID)
GEWENIG3  74 PL 52B 108           GEWENIGER,GJESDAL,PRESSER +      (CERN+HEID)
GJESDAL   74 PL 52B 113           +PRESSER,KAMAE,STEFFEN+          (CERN+HEID)

MESSNER   74 PRL 33 1458          +FRANKLIN,MORSE,NAUENBERG+ (COLO+SLAC+UCSC)
NIEBERGA  74 PL 49B 103           NIEBERGALL,REGLER,STIER +  (CERN+ORSA+VIEN)
WANG      74 PR D9 540            +SMITH,WHATLEY,ZORN,HORNBOSTEL    (UMD+BNL)
WILLIAMS  74 PRL 33 240           +LARSEN,LEIPUNER,SAPP,SESSOMS +  (BNL+YALE)
WOO       74 LNC 10 38            +BUCHANAN,PEPPER                      (UCLA)

BALDOCEO  75 NC 25A 688           BALDO-CEOLIN,BOBISUT,CALIMANI+  (PADO+WISC)
BLUMENTH  75 PRL 34 164           BLUMENTHAL,FRANKEL,NAGY +  (PENN+CHIC+TEMP)
BUCHANAN  75 PR D11 457           +DRICKEY,PEPPER,RUDNICK +   (UCLA+SLAC+JHU)
CARITHER  75 PRL 34 1244          CARITHERS,MODIS,NYGREN,PUN +      (COLU+NYU)
SMITH     75 UCSD THESIS-UNPUB    JAMES G. SMITH                        (UCSD)

BIRULEV   76 SJNP 24, 178         +VESTERGOMBI,VOVENKO,VOTRUBA,GENCHEV+(JINR)
COOMBES   76 PRL 37 249           +FLEXER,HALL,KENNELLY,KIRKBY +   (STAN+NYU)
DONALDSO  76 PR D14 2839          DONALDSON,HITLIN,KENNELLY,KIRKBY,LIU+(SLAC)
    ALSO 74 SLAC 184-THESIS   GREGORY J. DONALDSON                  (SLAC)
FUKUSHIM  76 PRL 36 348           FUKUSHIMA,JENSEN,SURKO,THALER+  (PRIN+MASA)
GJESDAL   76 NP B109 118          +KAMAE,PRESSER,STEFFEN +         (CERN+HEID)
REY       76 PR D13 1161          +CENCE,JONES,PARKER +       (NDAM+HAWA+LBL)
    ALSO 69 CENCE

CHO       77 PR D15 587           +DERRICK,LISSAUER,MILLER,ENGLER+ (ANL+CARN)
CLARK     77 PR D15 553           +FIELD,HOLLEY,JOHNSON,KERTH,SAH,SHEN  (LBL)
    ALSO 75 LBL-4275 THESIS   GILBERT SHEN                              (LBL)
DEVOE     77 PR D16 565           +CRONIN,FRISCH,GROSSO-PILCHER+    (EFI+ANL)
DZHORDZH  77 SJNP 26 478          DZHORDZHADZE,KEKELIDZE,KRIVOKHIZHIN+ (JINR)
PEACH     77 NP B127 399          +CAMERON +        (BGNA+EDIN+GLAS+PISA+RHEL)

ENGLER    78 PR D18 623           +KEYES,KRAEMER,TANAKA,CHO+        (CARN+ANL)
HILL      78 PL 73B 483           +SAKITT,SNAPE,STEVENS+      (BNL+SLAC+SBER)
CHRISTE1  79 PRL 43 1209          CHRISTENSON,GOLDMAN,HUMMEL,ROTH+       (NYU)
CHRISTE2  79 PRL 43 1212          CHRISTENSON,GOLDMAN,HUMMEL,ROTH+       (NYU)
HILL      79 NP B153 39           +SAKITT,SNAPE,STEVENS+      (BNL+SLAG+SBER)
SCHMIDT   79 PRL 43 556           +BLATT,CAMPBELL,GRANNAN+         (YALE+BNL)
SHOCHET   79 PR D19 1965          +LINSAY,GROSSO-PILCHER,FRISCH+    (EFI+ANL)
    ALSO 77 PRL 39 59         SHOCHET,LINSAY,GROSSO-PILCHER,+   (EFI+ANL)
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PAPERS NOT REFERRED TO IN DATA CARDS

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ALEXANDE 62 PRL 9 69            G ALEXANDER,S ALMEIDA,F CRAWFORD       (LRL)
JOVANOVI 63 BNL CONF 42         JOVANOVIC,FISCHER,BURRIS +   (BNL+MARYLAND)
STERN    64 PRL 12 459          STERN,BINFORD,LIND,ANDERSON +     (WISC+LRL)
BEHR     65 ARGONNE CONF 59     BEHR,BRISSON,BELLOTTI+      (EPOL,MILA,PADO)
MESTVIRI 65 JINR P 2449         MESTVIRISHVILI,NYAGU,PETROV,RUSAKOV+ (JINR)
TRILLING 65 UCRL 16473          GEORGE H TRILLING                      (LRL)
    UPDATED FROM 1965 ARGONNE CONF., PAGE 115.

GINSBERG 67 PR 162  1570        EDWARD S GINSBERG          (U. MASS BOSTON)
RUBBIA   67 PL  24B  531        C.RUBBIA,J.STEINBERGER           (CERN+COLU)
  ALSO 1 66 PL  20  207         ALFF-STEINBERGER,HEUER,KLEINKNECHT+  (CERN)
  ALSO 2 66 PL  21  595         ALFF-STEINBERGER,HEUER,KLEINKNECHT+  (CERN)
  ALSO 3 66 PL  23  167         C.RUBBIA,J.STEINBERGER           (CERN+COLU)
SCHMIDT  67 NEVIS 160(THESIS)   P. SCHMIDT                        (COLUMBIA)

CRONIN   68 VIENNA CONF P.281   CRONIN,RAPPORTEURS TALK          (PRINCETON)
BECHERRA 70 PR D1 1452          T BECHERRAWY                          (ROCH)
GINSBERG 70 PR D1 229           E S GINSBERG                     (IIT HAIFA)
HEUSSE   70 LNC  3 449          +AUBERT,PASCAUD,VIALLE               (ORSAY)
GINSBERG 73 PR D8 3887          E S GINSBERG, J SMITH             (MIT+STON)
KLEINKNE 76 ARNS 26 1           K. KLEINKNECHT                        (DCRT)
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$D^{\pm}$

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                  31   CHARGED D(1868,JP=0-)  I=1/2

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                  31   CHARGED D MASS (MEV)

M    L   50(1876.)     (15.)              PERUZZI   76 SMAG +- K-+PI+-PI+-        1/77
M    L     (1874.)      (5.)              GOLDHABER 77 SMAG +- DO,D+ RECOIL SPC  12/77
M     P     1868.3       0.9              PERUZZI   77 SMAG +- E+E- 3.77GEV ECM  12/77
M    L     (1874.)     (11.)              PICCOLO   77 SMAG +- E+E-4.03,4.41ECM   1/78
M    L   VALUES WITH LARGE ERRORS NOT AVERAGED.
M     P  ERROR DOES NOT INCLUDE 0.13 PERCENT UNCERTAINTY IN THE ABSOLUTE          3/78
M     P  SPEAR ENERGY CALIBRATION.  USES M(PSI)=3095 MEV.                         3/78

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                  31   (D+-) - (DO) MASS DIFFERENCE (MEV)

DM    P         5.0        0.8            PERUZZI   77 SMAG +- E+E- 3.77GEV ECM   3/78
DM    P  NOT INDEPENDENT OF PERUZZI 77 D+- AND DO MASSES.                         3/78

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                  31   CHARGED D MEAN LIFE    (UNITS 10**-13 SEC)

T               8.     OR LESS  CL=.90    ARMENISE  79 HYBR NEU P -->DIMUONS +    1/80*
T          1    2.5        3.5      1.5   BALLAGH   80 HYBR NEU P -->DILEPTON +   2/80*

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                  31   CHARGED D WIDTH FROM MASS SPECTRUM (MEV)

W     P  50   40.     OR LESS  CL=.90    PERUZZI   76 SMAG +- K-+PI+-PI+-        1/77
W     P         7.    OR LESS            PERUZZI   77 SMAG +- E+E- 3.77GEV ECM   3/78
W     P  PERUZZI WIDTHS ARE CONSISTENT WITH THEIR EXPERIMENTAL RESOLUTION.        1/77

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                  31   EVIDENCE FOR WEAK DECAY OF D

WK       70                               WISS     .76                            1/77
WK       WISS 76, USING A SAMPLE OF ABOUT 70 D+- --> K-+ PI+- PI+-                1/77
WK       EVENTS WHICH INCLUDE THE PERUZZI 76 EVENTS, FINDS THAT THIS FINAL        1/77
WK       STATE IS INCOMPATIBLE WITH NATURAL SPIN AND PARITY.  THE NATURAL         1/77
WK       SPIN PARITY FINAL STATE IN DO --> K- PI+ (GOLDHABER 76) INDICATES        1/77
WK       PARITY VIOLATION IN THE D+- AND DO DECAYS IF BOTH ARE MEMBERS OF         1/77
WK       THE SAME ISOMULTIPLET AS SUGGESTED BY THEIR SIMILAR MASSES.              1/77
WK       THIS SUGGESTS A WEAK DECAY AND CONSEQUENTLY A NARROW WIDTH OF ORDER      1/77
WK       10**13 SEC-1 OR 10**-8 MEV.                                              1/77

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                  31   CHARGED D  PARTIAL DECAY MODES

                                                              DECAY MASSES
P1       D+ INTO K- PI+ PI+                                 493+ 139+ 139
P2       D+ INTO KOBAR PI+                                  497+ 139
P3       D+ INTO PI+ PI+ PI-                                139+ 139+ 139
P4       D+ INTO PI+ K+ K-                                  139+ 493+ 493
P5       D+ INTO K+ PI+ PI-                                 493+ 139+ 139
P6       D+ INTO E+ NUE                                      .5+    0
P7       D+ INTO E+ ANYTHING
P8       D+ INTO K- ANYTHING
P9       D+ INTO KOBAR ANYTHING
P10      D+ INTO K+ ANYTHING
P11      D+ INTO K*(892)OBAR PI+                           1314+ 139

         D- MODES ARE CHARGE CONJUGATES OF THE ABOVE MODES

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                  31   CHARGED D BRANCHING RATIOS

R1       D+ INTO (K- PI+ PI+)/TOTAL                            (P1)
R1        85    0.039    0.010          PERUZZI   77 SMAG    E+E- 3.77GEV ECM 12/77

R2       D+ INTO (KOBAR PI+)/TOTAL                             (P2)
R2        17    0.015    0.006          PERUZZI   77 SMAG    E+E- 3.77GEV ECM 12/77

R3       D+ INTO (KOBAR PI+)/(K- PI+ PI+)                      (P2)/(P1)
R3    P          .45  OR LESS  CL=.90   PICCOLO   77 SMAG +- E+E- 4.03GEV ECM 12/77
R3    P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                            12/77

R4       D+ INTO (PI+ PI+ PI-)/(K- PI+ PI+)                    (P3)/(P1)
R4    P          .08  OR LESS  CL=.90   PICCOLO   77 SMAG +- E+E- 4.03GEV ECM 12/77
R4    P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                            12/77

R5       D+ INTO (PI+ K+ K-)/(K- PI+ PI+)                      (P4)/(P1)
R5    P          .15  OR LESS  CL=.90   PICCOLO   77 SMAG +- E+E- 4.03GEV ECM 12/77
R5    P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                            12/77

R6       D+ INTO (K+ PI+ PI-)/(K- PI+ PI+)                     (P5)/(P1)
R6    P          .05  OR LESS  CL=.90   PICCOLO   77 SMAG +- E+E- 4.03GEV ECM 12/77
R6    P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                            12/77

R7       (D+ INTO E+ NUE)/(D+ INTO E+ ANYTHING + DO INTO E+ ANYTHING)
R7              0.10  OR LESS  CL=.90   BRANDELIK 77 DASP E+E- 3.99-4.08 GEV  12/77
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Stable Particles

$D^{\pm}$, D^{0}, $F^{\pm}$

Data Card Listings

For notation, see key at front of Listings.

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R8      D+ AND DO INTO (E+ ANYTHING)/(TOTAL D+ AND DO)
R8            0.10      0.03            BRANDELIK 77 DASP E+E- 3.99-4.08 GEV    1/78
R8            0.072     0.028           FELLER    78 SMAG E+E- 3.772 GEV ECM    2/78
R8   B       (0.11)    (0.02)           BACINO    78 DLCO E+E- 3.772 GEV ECM    3/78
R8   B        0.08      0.015           BACINO    79 DLCO E+E- 3.772 GEV ECM   12/79*
R8   B   BACINO 79 REPLACES BACINO 78.                                         12/79*
R8          . . . . . . . . .
R8   AVG      0.082     0.012   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8   STUDENT  0.082     0.013   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R9      D+ INTO (K- ANYTHING)                        (P8)                       1/79*
R9        3    0.10     0.07            VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM    1/79*

R10     D+ INTO (KOBAR ANYTHING)                     (P9)                       1/79*
R10       3    0.39     0.29            VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM    1/79*

R11     D+ INTO (K+ ANYTHING)/TOTAL                  (P10)
R11       2    0.06     0.06            VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM    1/79*

R12     D+ INTO (K*(892)OBAR PI+)/TOTAL              (P11)
R12      92 EVENTS SEEN                 DRIJARD   79 SFM  + P P,ECM=53 GEV      7/79*

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                                REFERENCES FOR CHARGED D

GOLDHABE 76 PRL 37 255          GOLDHABER,PIERRE,ABRAMS,ALAM+       (LBL+SLAC)
PERUZZI  76 PRL 37 569          +PICCOLO,FELDMAN,NGUYEN,WISS+       (SLAC+LBL)
WISS     76 PRL 37 1531         +GOLDHABER,ABRAMS,ALAM,BOYARSKI+ (LBL+SLAC)

BRANDELI 77 PL 70B 387          BRANDELIK +          (AACH+DESY+HAMB+MPIM+TOKY)
GOLDHABE 77 PL 69B 503          GOLDHABER,WISS,ABRAMS,ALAM +        (LBL+SLAC)
PERUZZI  77 PRL 39 1301         +PICCOLO,FELDMAN+          (SLAC+LBL+NWES+HAWA)
PICCOLO  77 PL 70B 260          +PERUZZI,LUTH,NGUYEN,WISS,ABRAMS+(SLAC+LBL)

BACINO   78 PRL 40 671          +BAUMGARTEN,BIRKWOOD +         (SLAC+UCLA+UCI)
FELLER   78 PRL 40 274          +LITKE,MADARAS,RONAN+   (LBL+SLAC+NWES+HAWA)
VUILLEMI 78 PRL 41 1149         VUILLEMIN,FELDMAN +        (LBL+SLAC+NWES+HAWA)

ARMENISE 79 PL 86B 115          +ERRIQUEZ+            (BARI+CERN+EPOL+MILA+ORSA)
BACINO   79 PRL 43 1073         +FERGUSON,NODULMAN+        (UCLA+SLAC+UCI+STON)
DRIJARD  79 PL 81B 250          +FISCHER,GEIST+           (CERN+CDEF+HEID+KARL)
BALLAGH  80 PL 89B 423          +BINGHAM,FRETTER+ (LBL+FNAL+HAWA+WASH+WISC)

                                REVIEWS

BARBAROG 78 LBL-8537            A.BARBARO-GALTIERI (ERICE 1978)          (LBL)
WOJCICKI 78 SLAC-PUB-2232       S.WOJCICKI (SLAC SUMMER INST.1978)      (SLAC)
KIRKBY   79 SLAC-PUB-2419       J.KIRKBY (LEPTON CONF. BATAVIA 1979) (SLAC)

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D^0

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              32  NEUTRAL D(1863,JP=0-)  I=1/2
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              32  NEUTRAL D MASS (MEV)

M    L  234(1865.)    (15.)         GOLDHABER 76 SMAG     K PI AND K 3PI     1/77
M            1863.       3.         GOLDHABER 77 SMAG     DO,D+ RECOIL SPC  12/77
M    P       1863.3      0.9        PERUZZI   77 SMAG     E+E- 3.77GEV ECM  12/77
M    L      (1868.)    (11.)        PICCOLO   77 SMAG     E+E-4.03,4.41ECM   1/78
M    L   64(1850.)     (15.)        BALTAY    78 HBC      NEU NUCL,KOPIPI    1/79*
M        94 1854.        6.         ATIYA     79 SPEC GAMMA P-->DO DOBAR  12/79*
M         1 1866.        8.         ADAMOVICH 80 EMUL GAMMA NUC-->DOBAR +  2/80*
M    L   VALUES WITH LARGE ERRORS NOT AVERAGED.
M    P   ERROR DOES NOT INCLUDE 0.13 PERCENT UNCERTAINTY IN THE ABSOLUTE         3/78
M    P   SPEAR ENERGY CALIBRATION.  USES M(PSI)=3095 MEV.                         3/78
M           . . . . . . . . .
M    AVG        1863.12     0.85   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    STUDENT1863.15         0.92   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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              32  NEUTRAL D MEAN LIFE    (UNITS 10**-13 SEC)

T             8.0   OR LESS   CL=.90   ARMENISE  79 HYBR NEU P -->DIMUONS +   1/80*
T         1  (0.226)                   ADAMOVICH 80 EMUL GAMMA NUC-->DOBAR +  2/80*
T         2   3.5        3.5     1.7   BALLAGH   80 HYBR NEU P-->DILEPTON +   2/80*
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              32  NEUTRAL D WIDTH FROM MASS SPECTRUM (MEV)

W       234    40.    OR LESS              GOLDHABER 76 SMAG CHGD K PI AND K 3PI  1/77
W        30     2.0   OR LESS   CL=.90     FELDMAN   77 SMAG D*+ TO DO PI+        8/77
W        94   (20.)   OR LESS              ATIYA     79 SPEC GAMMA P-->DO DOBAR  12/79*
W       WIDTHS ARE CONSISTENT WITH EXPERIMENTAL RESOLUTION.                       3/77
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              32  NEUTRAL D PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      DO INTO K- PI+                                   493+ 139
P2      DO INTO K- PI+ PI+ PI-                           493+ 139+ 139+ 139
P3      DO INTO KOBAR PI+ PI-                            497+ 139+ 139
P4      DO INTO KOBAR PI+ PI- PI+ PI-                    497+ 139+ 139+ 139+
P5      DO INTO PI+ PI-                                  139+ 139
P6      DO INTO K+ PI- (VIA DOBAR)                       493+ 139
P7      DO INTO K+ K-                                    493+ 493
P8      DO INTO K- PI+ PIO                               493+ 139+ 134
P9      DO INTO KOBAR PIO                                497+ 134
P10     DO INTO E+ ANYTHING
P11     DO INTO K- ANYTHING
P12     DO INTO K+ ANYTHING
P13     DO INTO KOBAR ANYTHING

        DOBAR MODES ARE CHARGE CONJUGATES OF ABOVE MODES
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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

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          P 1         P 2        P 3        P 5        P 7
P 1  .0184+-.0049
P 2   .3052   .0350+-.0092
P 3   .2891    .0883   .0438+-.0111
P 5   .5034    .1537    .1456  .0006+-.0003
P 7   .7062    .2156    .2042    .3555  .0021+-.0008

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              32  NEUTRAL D BRANCHING RATIOS

R1      DO INTO (K- PI+)/TOTAL                              (P1)
R1      130    0.022    0.006           PERUZZI   77 SMAG    E+E- 3.77GEV ECM 12/77
R1          . . . . . . . . .
R1   FIT       0.0184   0.0049  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2      DO INTO (K- PI+ PI+ PI-)/TOTAL                      (P2)
R2       44    0.032    0.011           PERUZZI   77 SMAG    E+E- 3.77GEV ECM 12/77
R2          . . . . . . . . .
R2   FIT       0.0350   0.0092  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      DO INTO (KOBAR PI+ PI-)/TOTAL                       (P3)
R3       28    0.040    0.013           PERUZZI   77 SMAG    E+E- 3.77GEV ECM 12/77
R3          . . . . . . . . .
R3   FIT       0.044    0.011   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4      DO INTO (K- PI+ PI+ PI-)/(K- PI+)                   (P2)/(P1)
R4    P 214    2.2      0.8             PICCOLO   77 SMAG    E+E-4.03,4.41ECM 12/77
R4    P THIS CHANNEL DOMINATED BY K- PI+ RHOO (85+-15 PERCENT).               12/77
R4    P K* PI+ PI- AND K- A2+ CONSISTENT WITH 0, K* RHOO FRAC IS 0.1+-0.1 .   12/77
R4          . . . . . . . . .
R4   FIT       1.91     0.59    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5      DO INTO (KOBAR PI+ PI-)/(K- PI+)                    (P3)/(P1)
R5      116    2.8      1.0             PICCOLO   77 SMAG    E+E-4.03,4.41ECM 12/77
R5          . . . . . . . . .
R5   FIT       2.39     0.74    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6      DO INTO (PI+ PI-)/(K- PI+)                          (P5)/(P1)
R6            0.07   OR LESS  CL=.90   PICCOLO   77 SMAG    E+E- 4.03 GEVECM 12/77
R6            0.033    0.015           ABRAMS    79 SMK2    E+E- 3.77GEV ECM 12/79*
R6          . . . . . . . . .
R6   FIT       0.033    0.015   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R7      DO INTO (K+ K-)/(K- PI+)                            (P7)/(P1)
R7            0.07   OR LESS  CL=.90   PICCOLO   77 SMAG    E+E- 4.03GEV ECM 12/77
R7            0.113    0.030           ABRAMS    79 SMK2    E+E- 3.77GEV ECM 12/79*
R7          . . . . . . . . .
R7   FIT       0.113    0.030   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R8      DO INTO (K+ PI- VIA DOBAR)/(K- PI+ + K+ PI-)        (P6)/(P1+P6)
R8       THIS IS THE DO-DOBAR MIXING LIMIT
R8            0.16   OR LESS  CL=.90   FELDMAN   77 SMAG     D*+ TO DO PI+     3/77
R8            0.18   OR LESS  CL=.90   GOLDHABER 77 SMAG                      12/77

R9      DO INTO (K- PI+ PIO)/TOTAL                          (P8)
R9        7    0.12     0.06           SCHARRE   78 SMAG    E+E- 3.77 GEV      1/78

R10     DO INTO (KOBAR PIO)/TOTAL                           (P9)
R10           0.06   OR LESS  CL=.90   SCHARRE   78 SMAG    E+E- 3.77 GEV      1/78

R11     DO INTO (K- ANYTHING + K+ ANYTHING)/TOTAL           (P11+P12)
R11      19    0.35     0.10           VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM    1/79*

R12     DO INTO (KOBAR ANYTHING)/TOTAL                      (P13)
R12       6    0.57     0.26           VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM    1/79*

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                                REFERENCES FOR NEUTRAL D

GOLDHABE 76 PRL 37 255          GOLDHABER,PIERRE,ABRAMS,ALAM+      (LBL+SLAC)
FELDMAN  77 PRL 38 1313         +PERUZZI,PICCOLO,ABRAMS,ALAM +     (SLAC+LBL)
GOLDHABE 77 PL 69B 503          GOLDHABER,WISS,ABRAMS,ALAM +       (LBL+SLAC)
PERUZZI  77 PRL 39 1301         +PICCOLO,FELDMAN+          (SLAC+LBL+NWES+HAWA)
PICCOLO  77 PL 70B 260          +PERUZZI,LUTH,NGUYEN,WISS,ABRAMS+(SLAC+LBL)

BALTAY   78 PRL 41 73           +CAROUMBALIS,FRENCH,HIBBS,HYLTON+(COLU+BNL)
SCHARRE  78 PRL 40 74           +BARBARO-GALTIERI +       (SLAC+LBL+NWES+HAWA)
VUILLEMI 78 PRL 41 1149         VUILLEMIN,FELDMAN +       (LBL+SLAC+NWES+HAWA)

ABRAMS   79 PRL 43 481          +ALAM,BLOCKER,BOYARSKI+           (SLAC+LBL)
ARMENISE 79 PL 86B 115          +ERRIQUEZ+            (BARI+CERN+EPOL+MILA+ORSA)
ATIYA    79 PRL 43 414          +HOLMES,KNAPP,LEE+               (COLU+ILL+FNAL)
ADAMOVIC 80 PL 89B 427          (PHOTON-EMUL COLLAB + OMEGA-PHOTON COLLAB.)
BALLAGH  80 PL 89B 423          +BINGHAM,FRETTER+ (LBL+FNAL+HAWA+WASH+WISC)

        QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

NGUYEN   77 PRL 39 262          +WISS,ABRAMS,ALAM,BOYARSKI+        (LBL+SLAC)J

                                REVIEWS

BARBAROG 78 LBL-8537            A.BARBARO-GALTIERI (ERICE 1978)         (LBL)
WOJCICKI 78 SLAC-PUB-2232       S.WOJCICKI (SLAC SUMMER INST.1978)     (SLAC)

KIRKBY   79 SLAC-PUB-2419       J.KIRKBY (LEPTON CONF. BATAVIA 1979) (SLAC)

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$F^{\pm}$ →

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              34  F+-(2030,JP= )

              NEEDS CONFIRMATION.
              OMITTED FROM TABLE.
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              34  F+-(2030) MASS (MEV)

M    B     4(2030.)      (60.)          BRANDELIK 77 DASP +- E+E- ECM=4GEV     12/77
M    B     6 2030.        60.           BRANDELIK 79 DASP    E+E- ECM=4.42GEV   1/80*
M    B   BRANDELIK 77 EVENTS INCLUDED IN BRANDELIK 79 VALUE.                    1/80*
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              34  F+-(2030) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      F+- INTO ETA PI+-                                 548+ 139
P2      F+- INTO ETA ANYTHING                             548+   0
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

$F^{\pm}$, p, n

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                    34  F+-(2030) BRANCHING RATIOS

R1      F+- INTO (ETA PI+)/(ETA ANYTHING)                    (P1)/(P2)
R1        6     0.09      0.06           BRANDELIK 79 DASP     E+E- ECM=4.42GEV  1/80*

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                              REFERENCES FOR F+-(2030)
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BRANDELI 77 PL 70B 132         BRANDELIK +        (AACH+DESY+HAMB+MPIM+TCKY)
BRANDELI 79 PL 80B 412         BRANDELIK+         (AACH+DESY+HAMB+MPIM+TOKY)
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                    16  PROTON(938,J=1/2) I=1/2
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                    16  PROTON MASS (MEV)

M            (938.256)  (0.005)         COHEN      65 RVUE                    7/66
M            (938.2592) (0.0052)        TAYLOR     69 RVUE    USING NEW E/H   7/70
M             938.2796   0.0027         COHEN      73 RVUE                    3/74

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                    16  ANTIPROTON MASS  (MEV)

M1            938.3      0.5            BAMBERGER 70 CNTR                    12/79*
M1            938.179    0.058          HU         75 CNTR    EXOTIC ATOMS   12/79*
M1            938.229    0.049          ROBERSON   77 CNTR                   12/79*
M1            938.30     0.13           ROBERTS    78 CNTR                    6/78*
M1            . . . . . . . . .
M1   AVG      938.216    0.036    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M1   STUDENT  938.216    0.039    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    16  PROTON MEAN LIFE (UNITS 10**26 YR)

T            (.000001)OR MORE           GOLDHABE   54 TH 232 FISS.MODE INDEPEN
T              (0.002)OR MORE           FLEROV     57 TH 232 FISS.MODE INDEPEN
T    B          (1.5)  OR MORE          BACKENSTO  60 CNTR
T    B         (60.0)  OR MORE          KROPP      65 CNTR
T             (200.0)  OR MORE          GURR       67 CNTR DEP. ON DECAY MODE
T            (1300.0)  OR MORE          BERGAMASC  74 CNTR                   12/75
T    R      (20000.0)  OR MORE          REINES     74 CNTR                   12/75
T            10000.0   OR MORE          LEARNED    79 CNTR                   12/79*
T    B   KROPP AND BACKENSTOSS SENSITIVE TO PARTICULAR DECAY MODES OF PROTON
T    R   REINES 74 IS FOR DECAY CHAINS ENDING IN MUON DECAY.                 12/75

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                    16  ANTIPROTON MEAN LIFE  (HOURS)

T1          (3.3 E-8) OR MORE  CL=.95   GANGULI    78 HBC                     6/78*
T1   B        (32.)    OR MORE          BREGMAN    78                         7/79*
T1   E      (1700.)    OR MORE  CL=.90  BELL       79 ICE     PBAR-->E- PI0   1/80*
T1   G       1.E7 YR   OR MORE          GOLDEN     79 SPEC                   12/79*
T1   B   BREGMAN 78 STORED ANTIPROTONS IN ICE STORAGE RING AT CERN 85 HOURS.  7/79*
T1   E   BELL 79 STORED ANTIPROTONS IN ICE STORAGE RING FOR 10 DAYS. VALUE    1/80*
T1   E   GIVEN ABOVE IS LIFETIME/(BRANCHING RATIO TO E- PI0).                 1/80*
T1   G   GOLDEN 79 VALUE INFERRED FROM PBAR/P RATIO IN COSMIC RAYS.          12/79*

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                    16  PROTON MAGNET. MOMENT(E/2MP)

MM           (2.79276) (.00002)         COHEN      65 RVUE
MM           (2.792782)(.000017)        TAYLOR     69 RVUE    USING NEW E/H   7/70
MM            2.7928456 .0000011        COHEN      73 RVUE                    3/74

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                    16  ANTIPROTON MAGNETIC MOMENT (E/2MP)

MM1 O        (-1.8)     (1.2)           BUTTON     62 CNTR
MM1 R        (-2.83)    (0.10)          FOX        72 CNTR                   11/75
MM1 R        (-2.819)   (0.056)         ROBERTS    74 CNTR                    7/75
MM1           -2.791     0.021          HU         75 CNTR    EXOTIC ATOMS   12/79*
MM1  R        -2.817     0.048          ROBERTS    78 CNTR                    6/78*
MM1 C    OLD EXPERIMENT WITH LARGE ERROR.  NOT AVERAGED.
MM1  R   ROBERTS 74 IS REANALYSIS OF FOX 72 DATA.  REPLACES OLD FOX VALUE.    7/75
MM1  R   ROBERTS 78 IS A REANALYSIS OF ROBERTS 74.                            6/78*
MM1           . . . . . . . . . .
MM1 AVG       -2.795     0.019    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
MM1 STUDENT   -2.795     0.021    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    16  PROTON ELECTRIC DIPOLE MOMENT (UNITS 10**-23 E CM)
             NONZERO VALUE IMPLIES VIOLATION OF T AND P IN EM INTERACTION

EDM      1G    700.      900.           HARRISON  69 MBR                     10/69
EDM          55000.    OR LESS          KHRIPLOVI 76                          1/78

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                    16  PROTON ELECTRON CHARGE DIFFERENCE (UNITS E)

DQ    D       1.0E-21 OR LESS           DYLLA      73        NEUTRALITY OF SF6  2/80*
DQ    D   ASSUMES THAT Q(NEUTRON)=Q(PROTON)-Q(E-).  SEE DYLLA 73 FOR A          2/80*
DQ    D   SUMMARY OF EXPERIMENTS ON THE NEUTRALITY OF MATTER.                   2/80*

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                              REFERENCES FOR PROTON
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GOLDHABE 54 PR 96 1157 FNOTE2 GOLDHABER,F REINES+          (LOS ALAMOS,BNL)
FLEROV   57 SOV PHYS DOK 3 79 FLEROV,KLOCHKOV,SKOBKIN,TERENTEV        (USSR)
BACKENST 60 NC   16   749     BACKENSTOSS,FRAUENFELDER,HYAMS +       (CERN)
BUTTON   62 PR 127 1297       J BUTTON,B MAGLIC                       (LBL)
COHEN    65 RMP 37 537        +DUMOND (N.AMER.AVIATION SCIENCE CENT.,CIT)
KROPP    65 PR 137 B 740      W R KROPP,F REINES    (CASE INST TECHNOLOGY)
GURR     67 PR   158  1321    GURR,KROPP,REINES,MEYER (CASE,JOHANNESBURG)

HARRISON 69 PRL    22  1263   HARRISON,SANDARS,WRIGHT  (CLARENDON OXFORD)
TAYLOR   69 RMP 41 375        +PARKER,LANGENBERG           (PRIN+UCI+PENN)
BAMBERGE 70 PL 33B 233        BAMBERGER,LYNEN,PIEKARZ+    (MPIH+CERN+KARL)
FOX      72 PRL 29 193        +BARNES,EISENSTEIN+(BNL+CARN+VPI+WILL+WYOM)
COHEN    73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
DYLLA    73 PR A7 1224        H.F.DYLLA, J.G.KING                     (MIT)
BERGAMAS 74 LNC 11 636        BERGAMASCO,PICCHI                 (TORI+FRAS)
REINES   74 PRL 32 493        +CROUCH                           (UCI+CASE)
ROBERTS  74 PRL 33 1181       +COX,ECKHAUSE+ (WILL+VPI+CARN+WYOM+CIT+BNL)
   ALSO  75 PR D12 1232       ROBERTS,COX +  (WILL+VPI+CARN+WYOM+CIT+BNL)
HU       75 NP A254 403       +ASANO,CHEN,CHENG,DUGAN+          (COLU+YALE)

KHRIPLOV 76 JETP 44 25        I.B.KHRIPLOVICH      (NUC.PHYS.INST.,SIBERIA)
ROBERSON 77 PR C16 1945       +KING,KUNSELMAN+     (WYOM+CIT+CARN+VPI+WILL)
BREGMAN  78 PL 78B 174        +CALVETTI,CARRON,CITTOLIN,HAUER,HERR+(CERN)
GANGULI  78 PL 74B 130        +MALHOTRA,RAGHAVAN,SUBRAMANIAN +      (TATA)
ROBERTS  78 PR D17 358        B. L. ROBERTS                     (WILL+RHEL)

BELL     79 PL 86B 215        +CALVETTI,CARRON,CHANEY,CITTOLIN+     (CERN)
GOLDEN   79 PRL 43 1196       +HORAN,MAUGER,BADHWAR,LACY+      (NASA+PSLL)
LEARNED  79 PRL 43 907        +REINES,SONI                            (UCI)

        QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

KALOGERO 76 PRL 37 1037       KALOGEROPOULOS,CHIU,SUDARSHAN   (SYRA+TEXA)P
FRANKLIN 77 PR D16 910        JERROLD FRANKLIN                      (HAIF)P
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                    17  NEUTRON(939,J=1/2) I=1/2
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                    17  NEUTRON MASS (MEV)

M    T       (939.5527) (0.0052)        TAYLOR     69 RVUE    USING NEW E/H    7/70
M    T        939.5731   0.0027         COHEN      73 RVUE                     3/74
M    T   THESE DETERMINATIONS OF NEUTRON MASS NOT INDEPENDENT OF               7/70
M    T   NEUTRON-PROTON MASS DIFFERENCE MEASUREMENTS BELOW.                    7/70

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                    17  (NEUTRON) - (PROTON) MASS DIFFERENCE (MEV)

D    M       (1.29344)(0.00007)         MATTAUCH   65 RVUE                     3/71
D             1.293429 0.000036         COHEN      73 RVUE                     3/74
D    M   WE HAVE CONVERTED MATTAUCH NEUTRON-HYDROGEN MASS DIFFERENCE TO        3/71
D    M   NEUTRON-PROTON MASS DIFFERENCE USING CURRENT VALUE OF ELECTRON MASS   3/71
D    M   AND A HYDROGEN BINDING ENERGY OF 13.6 EV.                             3/71

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                    17  NEUTRON MEAN LIFE (UNITS 10**3 SEC)

         THE MEASUREMENT OF THE NEUTRON MEAN LIFE BY SOSNOVSKII 59 HAS
         BEEN DISCARDED SINCE 1.  IT DISAGREES WITH THE BETTER AND MORE
         RECENT RESULT OF CHRISTENSEN 67.  2.  THE VALUE OF GA/GV DE-
         RIVED FROM THE NEW VALUE OF THE MEAN LIFE AGREES WELL WITH THE
         GA/GV VALUE OBTAINED FROM THE FREE NEUTRON DATA.

T    E        (1.012)   (0.021)         SOSNOVSKI 59 PILE                      7/68
T             (0.935)   (0.014)         CHRISTENS 67 PILE REPL BY CHRISTENS72  3/68
T              0.918     0.014          CHRISTENS 72 PILE                      6/72
T              0.877     0.078          BONDARENK 78 PILE                      1/80*
T             . . . . . . . . .
T    AVG       0.917     0.014     0.014  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T    STUDENT   0.917     0.015     0.015  AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
     E   ERROR CHANGED BECAUSE ERROR IN CROSS SECTION FOR NEUTRON ABSORPTION
     E   IN GOLD HAS BEEN REDUCED.

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                    17  NEUTRON MAGNETIC MOMENT (MAGNETONS,938.2 MEV)

MM       (-1.913148    0.000066)        COHEN      56 RVUE                     7/66
MM       (-1.91304211 0.00000088)       GREENE     77 MRS  REPL. BY GREENE 79  3/78
MM        -1.91304184 0.00000088        GREENE     79 MRS                     12/79*

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                    17  NEUTRON ELECTRIC DIPOLE MOMENT (UNITS 10**-23 E CM)
               TEST OF CP OR T VIOLATION IN THE EM INTERACTION

EDM M      (-20.)     (30.)             MILLER     67 MRS                      1/78
EDM          +24.       39.             SHULL      67 CNTR                     1/78
EDM  M      (30.)    OR LESS            DRESS      68 MRS  ABSOLUTE VALUE      1/78
EDM          (5.)    OR LESS            BAIRD      69 MRS  INCLUDED IN DRESS73 10/69
EDM          - 2.       39.             APOSTOLES 70 MRS                       1/78
EDM           0.32      0.75            DRESS      73 MRS  .LT.10**-23 CL=.80  6/73
EDM  D        0.04      0.15            DRESS      77 MRS                      6/77
EDM  M   DRESS 68 INCLUDES DATA OF MILLER 67.                                  1/78
EDM  D   THE DRESS 77 RESULT IS EQUIV TO EDM < 3 E-24 (CL=.90)                 6/77
EDM          . . . . . . . . . .
EDM AVG       0.05      0.15     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
EDM STUDENT   0.05      0.16     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    17  NEUTRON CHARGE

      SEE SECTION DQ IN THE PROTON DATA CARD LISTINGS ABOVE

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                    17  NEUTRON PARTIAL DECAY MODES

                                                             DECAY MASSES
                                                             DECAY MASSES
P1       NEUTRON INTO PROTON E- ANTI(NUE)                   938+  .5+   0
P2       NEUTRON INTO PROTON NUE ANTI(NUE)                  938+   0+   0

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                    17  NEUTRON BRANCHING RATIOS

R1       NEUTRON INTO (PROTON NUE ANTI(NUE))/(PROTON E- ANTI(NUE)  (P2)/(P1)
R1    S       3. E-17 OR LESS           SUNYAR     60 CNTR RB87-->SR87M+NEUTRL  2/80*
R1            3. E-19 OR LESS           NORMAN     79 CNTR RB87-->SR87M+NEUTRL  2/80*
R1    S  WE HAVE CONVERTED SUNYAR 60 MEAN LIFE LIMIT FOR (N --> P + NEUTRLS)    2/80*
R1    S  AS DESCRIBED IN NORMAN 79.                                             2/80*

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                    17  NEUTRON BETA DECAY PARAMETERS

        RELATED TEXT SECTION VI D.1

AV      GA/GV  (SEE TEXT FOR SIGN CONVENTION)
AV  C       (-1.250)   (0.044)          CONFORTO  67 RVUE  SEE NOTE C BELOW
AV  EP      (-1.23)    (0.01)           CHRISTENS 67 CNTR  N DECAY FT VALUE    11/68
AV  P       (-1.22)    (0.08)           GRIGOREV  68 CNTR E-NEU ANG CORREL     10/71
AV  P       (-1.26)    (0.02)           CHRISTENS 70 CNTR PE,NEUT SPIN CORREL 10/71
AV  EP      (-1.27)    (0.025)          EROZOLIMS 71 CNTR PE,NEUT SPIN CORREL 10/71
AV  EP      (-1.239)   (0.011)          CHRISTENS 72 CNTR    N DEC.+ FT VALUE  1/73
AV  P       (-1.263)   (0.016)          KROPF     73 RVUE    N DECAY ALONE     1/73
AV   P       -1.250     0.009           KROPF     73 RVUE    N DEC.+ FT VALUE  1/73
AV  ES      (-1.250)   (0.036)          DOBROZEMS 75 CNTR E-NEU ANG CORREL.   12/75
AV   K       -1.253     0.021           KROHN     75 CNTR PE,NEUT SPIN CORREL  1/77
AV           -1.263     0.015           EROZOLIMS 77 CNTR PE,NEUT SPIN CORREL  1/78
AV  E S      -1.259     0.017           STRATOWA   78 CNTR PROTON RECOIL SPECT 7/79*
AV  C   CONFORTO 67 COMBINES FREE NEUTRON DATA TO 1967.  REPL. BY KROPF 73.    1/73
AV  E   THESE EXPERIMENTS MEASURE THE ABSOLUTE VALUE OF GA/GV ONLY            10/71
AV   P  KROPF 73 VALUE OBTAINED BY FITTING ALL DATA THROUGH 1972.              1/73
AV   K  KROHN 75 PAPER GIVES -1.258+-.015 INCLUDING EVENTS OF CHRISTENS 70.    1/78
AV   K  THE VALUE QUOTED ABOVE IS DERIVED FROM HIS A,BASED ON NEW EXPT ONLY    1/77
AV   S  STRATOWA 78 IS FINAL RESULT OF DOBROZEMS 75 EXPT.                      7/79*
AV            . . . . . . . . . .
AV  AVG      -1.2543    0.0067  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AV  STUDENT  -1.2542    0.0073  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

F       PHASE ANGLE OF GA RELATIVE TO GV  (DEGREES)
F   P     (175.)     (10.)              BURGY     60 CNTR    POLAR. NEUTRONS   6/77
F   P     (198.)     (27.)              CLARK     60 CNTR    POLAR. NEUTRONS   6/77
F   C     (176.1)     (6.4)             CONFORTO  67 RVUE                     11/68
F   P     (181.3)     (1.3)             EROZOLIMS 70 CNTR   POLAR. NEUTRON    10/69
F    P     181.1       1.3              KROPF     73 RVUE    N DECAY           1/73
F          180.35      0.43             EROZOLIMS 74 CNTR    POLAR. NEUTRONS   6/77
F          180.14      0.22             STEINBERG 74 CNTR    POLAR. NEUTRONS   6/77
F          179.71      0.39             EROZOLIMS 78 CNTR    POLAR. NEUTRONS   7/79*
F   C   CONFORTO 67 COMBINES FREE NEUTRON DATA TO 1967.  REPL. BY KROPF 73.    1/73
F    P  KROPF 73 VALUE OBTAINED BY FITTING ALL DATA THROUGH 1972.              1/73
F             . . . . . . . . . .
F   AVG    180.11      0.17     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
F   STUDENT 180.11     0.19     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

D1     THREE-VECTOR CORRELATION COEFFICIENT                                    7/76
D1     D1 MEASURES COMPONENT OF NEUTRON SPIN PERPENDICULAR TO THE DECAY        7/76
D1     PLANE IN BETA DECAY. SHOULD BE ZERO IF T-INVARIANCE NOT                 7/76
D1     VIOLATED.  SEE TEXT SEC VI D.                                           7/76
D1            -0.01        .01          EROZOLIMS 70 CNTR    POLAR. NEUTRONS   7/76
D1            -0.0027      .0033        EROZOLIMS 74 CNTR    POLAR. NEUTRONS   7/76
D1            -0.0011      .0017        STEINBERG 74 CNTR    POLAR. NEUTRONS   7/76
D1            +0.0022      .0030        EROZOLIMS 78 CNTR    POLAR. NEUTRONS   7/79*
D1            . . . . . . . . . .
D1  AVG      -0.0009    0.0013  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D1  STUDENT  -0.0009    0.0015  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                              REFERENCES FOR NEUTRON

COHEN    56 PR 104 283          V W COHEN, CORNGOLD, RAMSEY   (BNL+HARVARD)
SOSNOVSK 59 JETP  9  717        SOSNOVSKII,SPIVAK,PROKOFEV +   (IAE MOSCOW)
BURGY    60 PR 120 1829         +KROHN,NOVEY,RINGO                (ANL+CHIC)
CLARK    60 CJP 38 693          +ROBSON
SUNYAR   60 PR 120 871          A.W.SUNYAR, M.GOLDHABER               (BNL)

MATTAUCH 65 NP 67 1             +THIELE,WAPSTRA      (MAX PLANCK INST.CHEM.)
CHRISTEN 67 PL 26B 11           CHRISTENSEN,NIELSON,BAHNSEN,BROWN+   (RISO)
CONFORTO 67 APAH 22 15          G. CONFORTO                          (CERN)
MILLER   67 PRL 19 381          +DRESS,BAIRD,RAMSEY             (ORNL+HARV)
SHULL    67 PRL 19 384          C.G.SHULL, R.NATHANS              (MIT+BNL)
DRESS    68 PR 170 1200         +BAIRD,MILLER,RAMSEY            (ORNL+HARV)
GRIGOREV 68 SJNP 6 239          +GRISHIN,VLADIMIRSKII,NIKOLAEVSKII + (ITEP)

BAIRD    69 PR  179  1285       +MILLER,DRESS,RAMSEY            (ORNL,HARV)
TAYLOR   69 RMP 41 375          +PARKER,LANGENBERG          (PRIN+UCI+PENN)
APOSTOLE 70 RRP 15 343          APOSTOLESCU,IONESCU,IONESCU-BUJOR +  (BUCH)
CHRISTEN 70 PR C1 1693          CHRISTENSEN,KROHN,RINGO               (ANL)
EROZOLIM 70 SJNP 11 583         EROZOLIMSKI,BONDARENKO,  +           (KIAE)
    ALSO    PL 27B 557          EROZOLIMSKY,BONDARENKO  +            (KIAE)

EROZOLIM 71 JETPL 13 252        EROZOLIMSKII,BONDARENKO +            (KIAE)
CHRISTEN 72 PR D5 1628          CHRISTENSEN,NIELSON,BAHNSEN,BROWN+   (RISO)
COHEN    73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
DRESS    73 PR D7 3147          DRESS,MILLER,RAMSEY             (ORNL+HARV)
KROPF    73 ZPHY TO BE PUBL.    A KROPF,H PAUL                       (LINZ)
    ALSO 70 NP A154 160         H PAUL                               (VIEN)

EROZOLIM 74 JETPL 20 345        EROZOLIMSKII,MOSTOVOI,FEDUNIN,FRANK+
STEINBER 74 PRL 33 41           STEINBERG,LIAUD,VIGNON,HUGHES   (YALE+GREN)
    ALSO 76 PR D13 2469         STEINBERG,LIAUD,VIGNON,HUGHES   (YALE+GREN)
DOBROZEM 75 PR D11 510          DOBROZEMSKY,KERSCHBAUM,MORAW,PAUL +  (SEIB)
KROHN    75 PL 55B 175          KROHN,RINGO                           (ANL)

DRESS    77 PR D15 9            +MILLER,PENDLEBURY,PERRIN+ (ORNL+GREN+HARV)
EROZOLIM 77 JETPL 23 663        EROZOLIMSKII,FRANK,MOSTOVOI+         (KIAE)
GREENE   77 PL 71B 297          +RAMSEY,MAMPE+    (HARV+ILLG+SUSS+ORNL+CENG)
EROZOLIM 78 SJNP 28 48          EROZOLIMSKII,MOSTOVOI,FEDUNIN,FRANK+ (KIAE)
STRATOWA 78 PR D18 3970         +DOBROZEMSKY,WEINZIERL               (SEIB)
BONDAREN 78 JETPL 28 303        BONDARENKO,KURGUZOV,PROKOFEV+        (KIAE)

GREENE   79 PR D20 2139         +RAMSEY,MAMPE+    (HARV+ILLG+SUSS+ORNL+CENG)
NORMAN   79 PRL 43 1226         E.B.NORMAN, A.G.SEAMSTER             (WASH)

                                PAPERS NOT REFERRED TO IN DATA CARDS

JACKSON  57 PR 106 517          JACKSON,TREIMAN,WYLD            (PRINCETON)
COHEN    65 RMP 37 537          +DUMOND (N.AMER.AVIATION SCIENCE CENT.,CIT)
BHALLA   66 PL 19  691          C P BHALLA                        (ALABAMA)

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                    18  LAMBDA(1115,JP=1/2+) I=0
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                    18  LAMBDA MASS (MEV)

M   N   SINCE OUR FINAL VALUES FOR THE SIGMA AND LAMBDA MASSES COME FROM
M   N   DOING AN OVERALL FIT TO ALL MEASURED MASSES AND MASS DIFFERENCES,
M   N   WE HAVE USED THE UNCORRELATED MEASUREMENTS FROM SCHMIDT 65 RATHER
M   N   THAN THE ONES COMING FROM THE OVERALL FIT REPORTED IN THAT PAPER.
M   N   SINCE THERE SEEMS TO BE NO CONVINCING ARGUMENT AS TO WHY ONE SHOULD
M   N   IGNORE DATA USING RANGE MEASUREMENTS, WE HAVE INCLUDED HERE VALUES
M   N   DEPENDING ON PROTON AND PION RANGES.  THE SCHMIDT 65 MASSES HAVE
M   N   BEEN REEVALUATED USING OUR APRIL 1973 PROTON AND CHARGED K AND PI
M   N   MASSES.  P. SCHMIDT, PRIVATE COMMUNICATION, (1974).

M          1115.44      0.12           BHOWMIK    63 RVUE +  SEE NOTE L BELOW
M   L   ABOVE LAMBDA MASS HAS BEEN RAISED 35 KEV TO ACCOUNT FOR 46 KEV
M   L   INCREASE IN PROTON MASS AND 11 KEV DECREASE IN CHARGED PION MASS.
M   S   635(1115.86)   (0.09)          BALTAY     65 HBC    ERROR IS STATIS.    6/66
M       488 1115.65     0.07           SCHMIDT    65 HBC  SEE NOTE N            3/74
M   S 1147(1115.74)    (0.04)          CHIEN      66 HBC       6.9 PBAR P       9/67
M   S   972(1115.69)   (0.05)          CHIEN      66 HBC       6.9 PBAR PANTIL  9/67
M          1115.6       0.4            LONDON     66 HBC                        6/66
M         (1116.0)     (0.2)           BADIER     67 HBC     2.4 PBAR P,LLBAR   8/67
M       195 1115.39     0.12           MAYEUR     67 EMUL                      11/67
M   B 1524(1115.52)    (0.03)          BOHM       70 EMUL                       3/72
M       935 1115.59     0.08           HYMAN      72 HEBC                      11/71
M   B   AVERAGE OF VERY INCONSISTENT DATA. ERROR STATISTICAL ONLY. AUTHORS      3/72
M   B   DETECT SYSTEMATIC EFFECT OF ABOUT .15 MEV, WHICH THEY ATTRIBUTE         3/72
M   B   TO ERROR IN RANGE-ENERGY RELATIONS, IN REGION BETA=0.6-0.7.             3/72
M   B   THIS EFFECT, IF CONFIRMED, WOULD AFFECT VERY LITTLE THE VALUES OF       3/72
M   B   BHOWMICK 63 AND MAYEUR 67.
M   S   ERROR PURELY STATISTICAL.
M             . . . . . . . . . .
M   AVG      1115.566     0.056    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
M   STUDENT1115.568       0.053    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M   FIT      1115.596     0.046    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)  2/80*
                                   (SEE IDEOGRAM BELOW )
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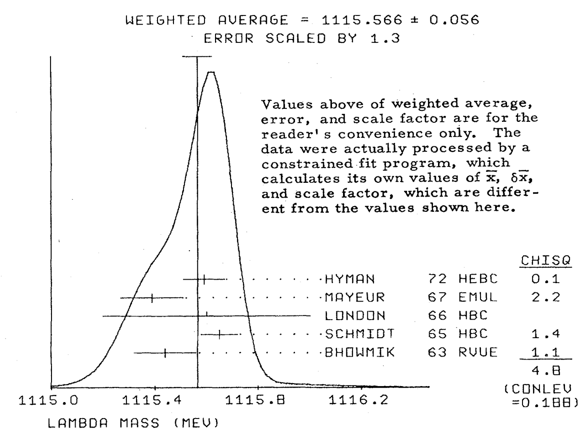


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                    18  LAMDA - ANTILAMBDA MASS DIFFERENCE (MEV)
DM              0.05      0.06              CHIEN     66 HBC      6.9 PBAR P        9/67
DM              0.29      0.15              BADIER    67 HBC     2.4 PBAR P         8/67
DM            . . . . . . . . . .
DM  AVG         0.083     0.083    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
DM  STUDENT     0.080     0.063    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    18  LAMBDA MEAN LIFE (UNITS 10**-10)

T   O  188   (2.63)   (0.21)   (0.21) BOLDT     58 CC
T   O  825   (2.72)   (0.16)   (0.16) CRAWFORD  59 HBC
T   O  140   (2.72)   (0.29)   (0.27) BOWEN     60 CC
T   O  186   (2.60)   (0.28)   (0.20) CHANG     62 HBC
T   O  799   (2.69)   (0.11)   (0.11) HUMPHREY  62 HBC
T   O 2239   (2.36)   (0.06)   (0.06) BLOCK     63 HEBC
T   O  706   (2.76)   (0.20)          CHRETIEN  63 HLBC
T   O  794   (2.59)   (0.09)          HUBBARD   64 HBC
T   O 2260   (2.31)   (0.10)          KREISLER  64 OSPK
T   O 1378   (2.59)   (0.07)          SCHWARTZ  64 HBC
T   O  635   (2.51)   (0.16)          BALTAY    65 HBC                       6/66
T   O 2534   (2.6)    (0.1)           HILL      65 OSPK
T   O  916   (2.35)   (0.09)          BURAN     66 HLBC                      6/66
T   S 1147   (2.50)   (0.14)          CHIEN     66 HBC      6.9 PBAR P       9/67
T   S  972   (2.70)   (0.20)          CHIEN     66 HBC      6.9 PBAR P,ANTI  9/67
T   O 2213   (2.452)  (0.056)  (0.054)ENGELMANN 66 HBC                       9/66
T   O  585   (2.68)   (0.13)   (0.11) AUERBACH  67 OSPK                      8/67
T   O        (2.44)   (0.15)          BADIER    67 HBC     2.4 PBAR P        6/68
T   O        (2.55)   (0.15)          BADIER    67 HBC     2.4 PBAR P,ANTIL  6/68
T   O 8342   (2.535)  (0.035)         GRIMM     68 HBC                       6/68
T   O 2600   (2.47)   (0.08)          HEPP      68 HBC                       8/68
T   O 1059   (2.39)   (0.10)          DEMIDOV   70 HLBC PI-P, 3.86 GEV/C    12/70
T   O 4572   (2.54)   (0.04)          BALTAY    71 HBC     K-P AT REST       6/71
T   O 6582   (2.69)   (0.05)          ALTHOFF2  73 OSPK    PI+N TO K+LAMBDA  2/74
T      36K    2.626    0.020          POULARD   73 HBC     K-P,KMOM .4TO2.3  9/73
T      34K    2.611    0.020          CLAYTON   75 HBC     K-P,KMOM .96-1.4  1/77
T      53K    2.69     0.03           ZECH      77 SPEC NEUTRAL HYP. BEAM   12/77
T   O   OLD LOWER STATISTICS EXPERIMENTS NOT INCLUDED IN AVERAGE.            1/78
T   S   ERROR PURELY STATISTICAL.
T             . . . . . . . . . .
T   AVG       2.632    0.020    0.020  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.6)
T   STUDENT   2.630    0.015    0.015  AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
                       (SEE IDEOGRAM BELOW )
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

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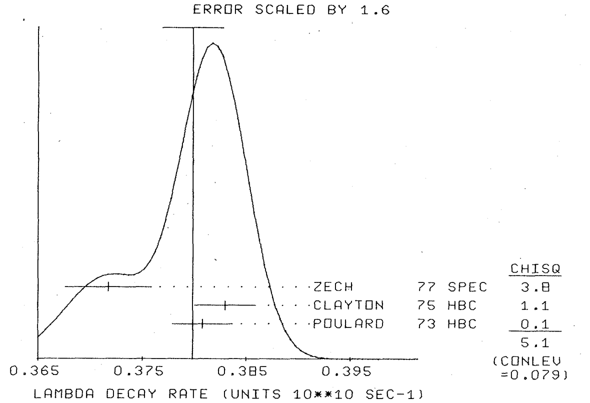
WEIGHTED AVERAGE = 0.3799 ± 0.0029
ERROR SCALED BY 1.6



LAMBDA DECAY RATE (UNITS 10**10 SEC-1)

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18  (LAMBDA - ANTILAMBDA)/AVG., MEAN LIFE DIFFERENCE

DT            0.044    0.085             BADIER     67 HBC      2.4 PBAR P        8/67
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18  LAMBDA MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM            -1.5      0.5              COOL       62 OSPK
MM             0.0      0.6              KERNAN     63 CC
MM    8553    -1.39     0.72             ANDERSON   64 HBC
MM     151    -0.5      0.28             CHARRIERE  65 EMUL
MM      49   (-0.67)   (0.31)   (0.37)   BARKOV     71 EMUL    PRELIM. RESULT      2/72
MM    1300    -0.66     0.07             DAHLJENSE  71 EMUL    MAG FIELD=200KG     6/71
MM    3868    -0.73     0.18             HILL       71 OSPK                       10/71
MM      57    -0.65     0.28             BARKOV     72 EMUL  INCLUDES BARKCV 71    3/78
MM    1.2M    -0.57     0.05             BUNCE      76 SPEC                        1/78
MM    350K    -0.59     0.07             HELLER     77 SPEC                        1/78
MM      3M    -0.6138   0.0047           SCHACHING  78 SPEC                        1/79*
MM             . . . . . . . . . .
MM  AVG       -0.6136   0.0047  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
MM  STUDENT   -0.6136   0.0050  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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18  LAMBDA ELECTRIC DIPOLE MOMENT (UNITS 10**-14 E CM)
    NONZERO VALUE IMPLIES VIOLATION OF T AND P

EDM           5.0    OR LESS  CL=.95    GIBSON     66 EMUL                          2/72
EDM  B        1.0    OR LESS  CL=.95    BARONI     71 EMUL                          2/72
EDM  B   BARONI MEASURES (-5.9+-2.9)*10**-15 E CM                                   2/72
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18  LAMBDA PARTIAL DECAY MODES

                                                        DECAY MASSES
P1    LAMBDA INTO PROTON PI-                            938+ 139
P2    LAMBDA INTO NEUTRON PIO                           939+ 134
P3    LAMBDA INTO PROTON MU- NEUTRINO                   938+ 105+   0
P4    LAMBDA INTO PROTON E- NEUTRINO                    938+  .5+   0
P5    LAMBDA INTO PROTON PI- GAMMA                      938+ 139+   0
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18  LAMBDA BRANCHING RATIOS

R1     LAMBDA INTO (P PI-)/((P PI-)+(N PIO))                 (P1)/(P1+P2)
R1              0.627    0.031          CRAWFORD  59 HBC
R1              0.65     0.05           COLUMBIA  60 HBC
R1  U          (0.685)  (0.017)         ANDERSON  62 HBC
R1     903      0.643    0.016          HUMPHREY  62 HBC
R1 U  6736      0.635    0.007          DOYLE     69 HBC     PI-P TO LAM. KO   2/71
R1    4572      0.646    0.008          BALTAY    71 HBC     K-P AT REST       6/71
R1  U   ANDERSON RESULT NOT PUBLISHED, EVENTS ADDED TO DOYLE SAMPLE.          2/71
R1          . . . . . . . . . .
R1  AVG         0.6399   0.0049  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT     0.6398   0.0055  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT         0.6419   0.0049 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2     LAMBDA INTO (N PIO)/((P PI-)+(N PIO))                 (P2)/(P1+P2)
R2              0.23     0.09           EISLER    57 HLBC
R2              0.43     0.14           CRAWFORD  59 HBC
R2              0.28     0.08           BAGLIN    60 HLBC
R2              0.35     0.05           BROWN     63 HLBC
R2      75      0.291    0.034          CHRETIEN  63 HLBC
R2          . . . . . . . . . .
R2  AVG         0.304    0.025   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  STUDENT     0.304    0.028   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2  FIT         0.3581   0.0049 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3     LAMBDA INTO (P E- NEU)/TOTAL (UNITS 10**-3)           (P4)/(P1+P2)
R3  O   15    (2.0)     (0.5)           HUMPHREY  61 RVUE
R3  O    8    (2.9)     (1.5)    (1.2)  AUBERT    62 FBC
R3  N  150    (0.82)    (0.12)          ELY       63 FBC     K- AT REST
R3  N  102    (0.78)    (0.12)   (0.13) BAGLIN    64 FBC     K- AT 1.45 GEV/C
R3  O   20    (1.55)    (0.34)          LIND      64 HBC
R3  N  143    (0.80)    (0.08)          MALCNEY   69 HBC                      10/69
R3  N   86    (0.78)    (0.09)          CANTER    71 HBC     K-P AT REST       4/71
R3  N  218    (0.88)    (0.10)          LINDQUIST 71 OSPK    PI- P TO KO LAM   2/72
R3  N   THESE VALUES HAVE BEEN CHANGED BY US INTO RATIOS TO PROTON PI-,        3/72
R3  N   BECAUSE THAT IS THE DIRECTLY MEASURED QUANTITY. SEE R5 BELOW           3/72
R3  O   LOW STATISTICS EXPERIMENTS.  NOT AVERAGED                              7/70

R4     LAMBDA INTO (P MU- NEU)/TOTAL (UNITS 10**-4)       (P3)/(P1+P2)
R4      1    (0.2)   OR MORE              GOOD      62 HBC
R4      1    (1.0)   OR LESS              ALSTON    63 HBC
R4      2    (1.0)   OR LESS              KERNAN    64 FBC
R4     BETWEEN 1.3 AND 6.0                LIND      64 HBC
R4      3     1.3       0.7               LIND      64 RVUE                     7/66
R4      2     1.5       1.2               RONNE     64 FBC
R4      9     2.4       0.8               CANTER1   71 HBC     STOPPED K-P      7/71
R4     14     1.4       0.5               BAGGETT2  72 HBC     STOP K-          8/72
R4          . . . . . . . . . .
R4  AVG       1.57      0.35    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4  STUDENT   1.56      0.38    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R5     LAMBDA INTO (P E- NEU)/(P PI-) (UNITS 10**-3)     (P4)/(P1)
R5    150     1.23      0.20              ELY       63 FBC                      2/72
R5    120     1.17      0.18              BAGLIN    64 FBC                      2/72
R5    143     1.20      0.12              MALCNEY   69 HBC                      2/72
R5   1078     1.31      0.06              ALTHOFF1  71 OSPK                     2/72
R5  C  86     1.17      0.13              CANTER    71 HBC     K-P AT REST      3/72
R5 LC 218    (1.32)    (0.15)             LINDQUIST 71 OSPK    PI-P TO KO LAM   3/72
R5  L 544     1.23      0.11              LINDQUIST 77 SPEC    PI-P TO KO LAM  12/77
R5  C  CALCULATED BY US FROM R3 ASSUMING THE AUTHORS USED (P PI-)/TOT=2/3     3/72
R5  L  LINDQUIST 77 INCLUDES DATA OF LINDQUIST 71.                           12/77
R5          . . . . . . . . . .
R5  AVG       1.257     0.043   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  STUDENT   1.256     0.048   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R6     LAMBDA INTO (P PI- GAMMA)/(P PI-) (UNITS 10**-3) (P5)/(P1)             1/73
R6     72     1.32      0.22              BAGGETT3  72 HBC  PI- MOM LT 95 MEV/C 1/73
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18  LAMBDA DECAY PARAMETERS

    RELATED TEXT SECTION VI D AND APPENDIX III

A-     ALPHA LAMBDA- (LAMBDA INTO PI- PROTON)
A-     1156    0.62      0.07             CRONIN    63 CNTR    LAMBDA FROM PI-P  8/67
A-            (0.663)   (0.022)           BERGE     66 RVUE  INCLUDES ABOVE      9/66
A-    10130    0.645     0.017            OVERSETH  67 OSPK    LAMBDA FROM PI-P  8/67
A-  M 2529    (0.747)   (0.086)           MERRILL   68 HBC  REPL BY DAUBER 68    6/68
A-     3520    0.67      0.06             DAUBER    69 HBC  FROM XI DECAY        6/68
A-    10325    0.649     0.023            CLELAND   72 OSPK    LAMBDA FROM PI-P  5/72
A-     8500    0.584     0.046            ASTBURY   75 SPEC    LAMBDA FROM PI-P  2/78
A-          . . . . . . . . . .
A-  AVG        0.642     0.013   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A-  STUDENT    0.642     0.014   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

AO     ALPHAO /ALPHA- FOR LAMBDA (L INTO PIO N/L INTO PI- P)
AO             1.10      0.27             CORK      60 CNTR
AO O  4760     1.000     0.068            OLSEN     70 OSPK PI+N TO K+ LAMBDA    5/70
AO          . . . . . . . . . .
AO  AVG        1.006     0.066   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AO  STUDENT    1.006     0.071   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
AO O    DONE BY CCMPARING PROTON DISTR.WITH N DISTR. FROM LAMBDA DECAY.

F-      PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA)   (DEGREES)
F-     1156    13.0      17.0             CRONIN    63 OSPK    LAMBDA FROM PI-P 11/67
F-    10130    -8.0       6.0             OVERSETH  67 OSPK    LAMBDA FROM PI-P 11/67
F-     7377   (-9.2)     (5.2)            CLELAND   67 OSPK REPL BY CLELAND 72   5/72
F-    10325    -7.0       4.5             CLELAND   72 OSPK    LAMBDA FROM PI-P  5/72
F-          . . . . . . . . . .
F-  AVG        -6.5       3.5    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
F-  STUDENT    -6.6       3.8    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

AV      GA/GV FOR LAMBDA BETA DECAY (SEE TEXT SEC. VI D.1 FOR SIGN CONV.)
AV  C   22   (-1.03)                      LIND      64 HBC                      6/68
AV  C  102    (0.6)   OR MORE             BAGLIN    65 HLBC    NO SIGN GIVEN    1/71
AV  C       BETW 0. AND -1.1              BARLOW    65 OSPK                     6/68
AV  C  102    (0.7)   OR MORE  CL=.95     ELY       65 HLBC     ABS. VALUE      1/71
AV  C   EXPERIMENTS INCLUDED IN CONFORTO 65, RVUE                               6/68
AV            -1.14      0.23      0.33   CONFORTO  65 RVUE                    11/67
AV M   148    -0.72      0.14      0.19   MALCNEY   69 HBC                     10/69
AV  A 1078   (-0.62)    (0.08)    (0.09)  ALTHOFF2  71 OSPK    POLARIZED LAMBDA 7/73
AV M   141    -0.75      0.15      0.18   CANTER    71 HBC                      4/71
AV  L  173   (-0.40)    (0.13)    (0.17)  LINDQUIST 71 OSPK   E-NEU AND UP-DOWN 9/71
AV M   352    -0.74      0.09      0.12   BAGGETT1  72 HBC     STOP.K-          2/72
AV A   817    -0.63      0.06             ALTHOFF1  73 OSPK    POLARIZED LAMBDA 7/73
AV     405    -0.47      0.09             BURNETT   76 SPEC    E-NEU AND SPIN   2/78
AV   L 441    -0.53      0.09      0.11   LINDQUIST 77 SPEC POL LAMBDA, 3 ASYMM 12/77
AV   A  ALTHOFF1 73 INCLUDES DATA OF ALTHOFF2 71.  USES PROT SPECTRUM AND       7/73
AV   A  THREE SPIN ASYMMETRIES.                                                  7/73
AV M    EXPT MEASURES ONLY THE ABSOLUTE VALUE OF A/V                            7/73
AV   L  LINDQUIST 77 INCLUDES DATA OF LINDQUIST 71.                            12/77
AV          . . . . . . . . . .
AV  AVG       -0.622     0.048   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
AV  STUDENT   -0.624     0.045   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                 (SEE IDEOGRAM BELOW )
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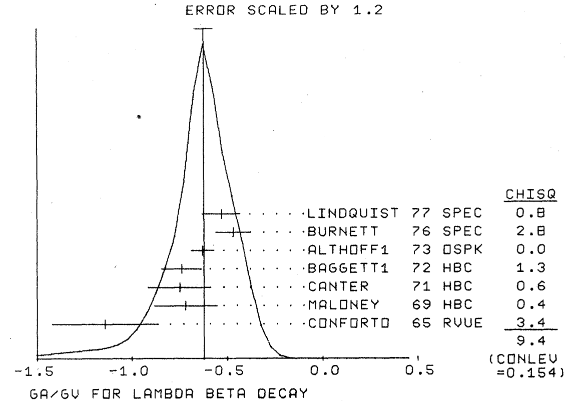
WEIGHTED AVERAGE = -0.622 ± 0.048
ERROR SCALED BY 1.2



GA/GV FOR LAMBDA BETA DECAY

Stable Particles

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Data Card Listings

For notation, see key at front of Listings.


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                              REFERENCES FOR LAMBDA

EISLER   57 NC     5 1700     EISLER,PLANO,SAMIOS,SCHWARTZ +     (COLU+BNL)
BOLDT    58 PRL    1  148     E BOLDT,D O CALDWELL,Y PAL              (MIT)
CRAWFORD 59 PRL    2  266     CRAWFORD,CRESTI,DOUGLASS,GOOD +         (LRL)

BAGLIN   60 NC    18 1043     BAGLIN,BLOCH,BRISSON,HENNESSY +        (EPOL)
BOWEN    60 PR   119 2030     BOWEN,HARDY,REYNOLDS,SUN +        (PRINCETON)
CORK     60 PR   120 1000     CORK,KERTH,WENZEL,CRONIN+    (LRL+PRIN+BNL)
COLUMBIA 60 ROCH CONF 726     M SCHWARTZ +                       (COLUMBIA)
HUMPHREY 61 PRL    6  478     HUMPHREY,KIRZ,ROSENFELD,RHEE +     (LRL+SYRA)

ANDERSON 62 CERN CONF 832     ANDERSON,CRAWFORD,GOLDEN,LLOYD +        (LRL)
AUBERT   62 NC    25  479     AUBERT,BRISSON,HENNESSY,SIX +          (EPOL)
CHANG    62 THESIS DUKE       CHUEN CHUEN CHANG                      (DUKE)
COOL     62 PR   127 2223     COOL,HILL,MARSHALL +        (BNL+MIT+NYU+ANL)
GOOD     62 PRL    9  518     M L GOOD,V G LIND                 (WISCONSIN)
HUMPHREY 62 PR   127 1305     W E HUMPHREY,R R ROSS                   (LRL)

ALSTON   63 UCRL 10926        ALSTON,KIRZ,NEUFELD,SOLMITZ,WOHLMUT     (LRL)
BHOWMIK  63 NC    28 1494     B BHOWMIK,D P GOYAL                   (DELHI)
BLOCK    63 PR   130  766     BLOCK,GESSAROLI,RATTI+(NWES+BGNA+SYRA+ORNL)
BROWN    63 PR   130  769     BROWN,KADYK,TRILLING,ROE +         (LRL+MICH)
CHRETIEN 63 PR   131  2208    CHRETIEN,CROUCH+   (BRAN+BROWN+HARVARD+MIT)
CRONIN   63 PR   129 1795     J W CRONIN,O E OVERSETH           (PRINCETON)
ELY      63 PR   131  868     ELY,GIDAL,KALMUS,OSWALD,POWELL +        (LRL)
KERNAN   63 PR   129  870     KERNAN,NOVEY,WARSHAW,WATTENBERG   (ANL+ILL)

ANDERSON 64 PRL   13  167     J A ANDERSON,F S CRAWFORD               (LRL)
BAGLIN   64 NC    35  977     BAGLIN,BINGHAM+  (EPOL+CERN+LOUC+RHEL+BERG)
HUBBARD  64 PR   135 B 183    HUBBARD,BERGE,KALBFLEISCH,SHAFER +      (LRL)
KERNAN   64 PR   133 B 1271   KERNAN,POWELL,SANDLER +            (LRL+LOUC)
KREISLER 64 PR 136 B 1074     M N KREISLER,O OVERSETH,J CRONIN       (PRIN)
LIND     64 PR   135 B 1483   LIND,BINFORD,GOOD,STERN           (WISCONSIN)
RONNE    64 PL    11   357    RONNE+          (CERN+EPOL+LOUC++UNIV.BERGEN)
SCHWARTZ 64 UCRL 11360 THESIS JOSEPH ADAM SCHWARTZ                    (LRL)

BAGLIN   65 NC 35 977         BAGLIN +          (EPOL,CERN,LOUC,RHEL,BERGEN)
BALTAY   65 PR 140 B 1027     BALTAY,SANDWEISS,CULWICK,KOPP +  (YALE+BNL)
BARLOW   65 PL   18   64      J BARLOW,BLAIR,CONFORTO+    (CERN+RHEL+PENN)
CHARRIER 65 PL    15      66  CHARRIERE,GIBSON+       (EPOL+BRIS+CERN+MPIM)
   ALSO  66 NC   46A  205     CHARRIERE,GIBSON +      (EPOL,BRIS,CERN,MPIM)
CONFORTO 65 EC INT HERZEGNOVI G CONFORTO                             (CERN)
ELY      65 PR 137 B1302      ELY,GIDAL,KALMUS,POWELL +         (LRL,LOUC)
HILL     65 PRL 15 85         HILL,LI,JENKINS,KYCIA,RUDERMAN     (MIT,BNL)
SCHMIDT  65 PR 140 B 1328     P SCHMIDT                          (COLUMBIA)

BERGE    66  BERKELEY 46      BERGE,CABIBBO              ((RVUE) LRL,CERN)
BURAN    66 PL 20 318         BURAN,EIVINDSON,SKJEGGESTAD,TOFTE +  (OSLO)
CHIEN    66 PR   152  1171    +LACH,SANDWEISS,TAFT,YEH,OREN +  (YALE+BNL)
ENGELMAN 66 NC 45A  1038      ENGELMANN,FILTHUTH,ALEXANDER+     (HEID,REHO)
GIBSON   66 NC 45A 882        W M GIBSON,K GREEN                     (BRIS)
LONDON   66 PR 143 1034       LONDON,RAU,GOLDBERG,LICHTMAN+     (BNL,SYRA)

AUERBACH 67 NC   47A  19      AUERBACH,BOWEN,DOBBS,LANDE,MANN+       (PENN)
BADIER   67 PL 25B 152        +BONNET,BRIANDET,SADOULET              (EPOL)
CLELAND  67 PL 26B 45         CLELAND,BIENLEIN,CONFORTO+ (CERN+GEVA+LUND)
MAYEUR   67 U.LIBR.BRUX.BUL32 C.MAYEUR,E.TOMPA,J.WICKENS        (BELG,LOUC)
OVERSETH 67 PRL   19  391     O E OVERSETH, R F ROTH            (MICH+PRIN)
GRIMM    68 NC 54A 187        H.-J.GRIMM                       (HEIDELBERG)
HEPP     68 ZPHYS 214 71      V.HEPP,H. SCHLEICH               (HEIDELBERG)
MERRILL  68 PR 167 1202       MERRILL,SHAFER                          (LRL)

DAUBER   69 PR   179 1262     +BERGE,HUBBARD,MERRILL,MILLER           (LRL)
DOYLE    69 UCRL 18139-THESIS J.C. DOYLE                              (LRL)
MALONEY  69 PRL 23 425        MALONEY,SECHI-ZORN          (UNIV MARYLAND)
BOHM     70 NC 70A 384        + KRECKER + (BERL+BRUX+DUUC+LOUC+LOWC+WARS)
DEMIDOV  70 SJNP 10 681       +KIRILLOV-UGRYUMOV,PONOSOV,PROTASOV+ (ITEP)
OLSEN    70 PRL 24 843        +PONDROM,HANDLER,LIMON,SMITH +  (WISC,MICH)

ALTHOFF1 71 PL 37B 531        +BROWN,FREYTAG,HEARD,HEINTZE +  (CERN,HEID)
ALTHOFF2 71 PL 37B 535        +BROWN,FREYTAG,HEARD,HEINTZE +  (CERN,HEID)
BALTAY   71 PR D4 670         +BRIDGEWATER,COOPER,HABIBI+     (COLU+BING)
BARKOV   71 JETPL 14 60       +GUREVICH,MAKARINA,MARTEMYANOV+        (ITEP)
BARONI   71 LNC 2 1256        G BARONI,S PETRERA,G ROMANO            (ROMA)
CANTER   71 PRL 26 868        +COLE,LEE-FRANZINI,LOVELESS +   (STON+COLU)

CANTER1  71 PRL 27 59         +COLE,LEE-FRANZINI,LOVELESS+    (STON+COLU)
DAHLJENS 71 NC 3A 1           DAHL-JENSEN +     (CERN+ANKA+LAUS+MPIM+ROMA)
HILL     71 PR D4 1979        +LI,JENKINS,KYCIA,RUDERMAN         (MIT,BNL)
   ALSO  65 PRL 15 85         HILL,LI,JENKINS,KYCIA,RUDERMAN     (MIT,BNL)
LINDQUIS 71 PRL 27 612        LINDQUIST,SUMNER+          (EFI,WUSL,OSU,ANL)

BAGGETT1 72 ZPHY 249 279      +BAGGETT,EISELE,FILTHUTH,FREHSE+       (HEID)
BAGGETT2 72 ZPHY 252 362      +BAGGETT,EISELE,FILTHUTH,FREHSE+       (HEID)
BAGGETT3 72 PL 42B 379        +BAGGETT,EISELE,FILTHUTH,FREHSE,HEPP+(HEID)
BARKOV   72 JETPL 16 104      +GUREVICH,MAKARINA,MARTEMYANOV +       (ITEP)
CLELAND  72 NP B40 221        +CONFORTO,EATON,GERBER+    (CERN+GEVA+LUND)
HYMAN    72 PR D5 1063        +BUNNELL,DERRICK,FIELDS,KATZ+     (ANL+CARN)

ALTHOFF1 73 PL 43B 237        +BROWN,FREYTAG,HEARD,HEINTZE+   (CERN+HEID)
ALTHOFF2 73 NP B66 29         +BROWN,FREYTAG,HEARD,HEINTZE+   (CERN+HEID)
POULARD  73 PL 46B 135        +GIVERNAUD,BORG                        (SACL)

ASTBURY  75 NP B99 30         +GALLIVAN,JAFAR +      (LOIC+CERN+ETH+SACL)
CLAYTON  75 NP B95 130        +BACON,BUTTERWORTH,WATERS +       (LOIC+RHEL)
BUNCE    76 PRL 36 1113       +HANDLER,MARCH,MARTIN +     (WISC+MICH+RUTG)
BURNETT  76 NC 34A 14         +INNES,MASEK,MAUNG,MILLER,RUDERMAN+  (UCSC)

HELLER   77 PL 68B 480        +OVERSETH,BUNCE,DYDAK +     (MICH+WISC+HEID)
LINDQUIS 77 PR D16 2104       LINDQUIST,SWALLOW,SUMNER +     (EFI+OSU+ANL)
   ALSO  76 JPG 2 L211        LINDQUIST,SWALLOW,SUMNER+(EFI+WUSL+OSU+ANL)
ZECH     77 NP B124 413       +DYDAK,NAVARRIA+        (SIEG+CERN+DORT+HEID)
SCHACHIN 78 PRL 41 1348       SCHACHINGER,BUNCE,COX +     (MICH+RUTG+WISC)

                              PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 62 CERN CONF 236     ARMENTEROS+ (CERN+EPOL+LOIC+BIRM+CEN-SACLAY)
BALTAY   62 CERN CONF 233     BALTAY,FOWLER,SANDWEISS,CULWICK+ (YALE+BNL)
BERGE    63 THESIS (BERKELEY) J PETER BERGE                           (LRL)

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                    19  SIGMA+(1189,JP=1/2+) I=1
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                    19  SIGMA+ MASS (MEV)

M    N SEE NOTE PRECEDING LAMBDA MASS LISTINGS

M       144 1189.38      0.15            BARKAS     63 EMUL +  SEE NOTE S BELOW
M        58 1189.48      0.22            BHOWMIK    64 EMUL +  SEE NOTE S BELOW
M    S  ABOVE SIGMA+ MASSES HAVE BEEN RAISED 30  KEV TO ACCOUNT FOR 46 KEV
M    S  INCREASE IN PROTON MASS AND 21 KEV DECREASE IN PION MASS
M      4205 1189.61      0.08            SCHMIDT    65 HBC  SEE NOTE N        3/74
M           1189.16      0.12            HYMAN      67 HEBC                   6/68
M     B 607 1189.33      0.04            BOHM       72 EMUL                  12/73
M     B  BOHM 72 UPDATED WITH PDG APR. 73 K-, PI- AND PIO MASSES.            12/73
M           . . . . . . . . .
M    AVG     1189.371     0.060   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
M    STUDENT1189.354      0.041   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M    FIT     1189.365     0.058  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)  2/80*
                          (SEE IDEOGRAM BELOW )
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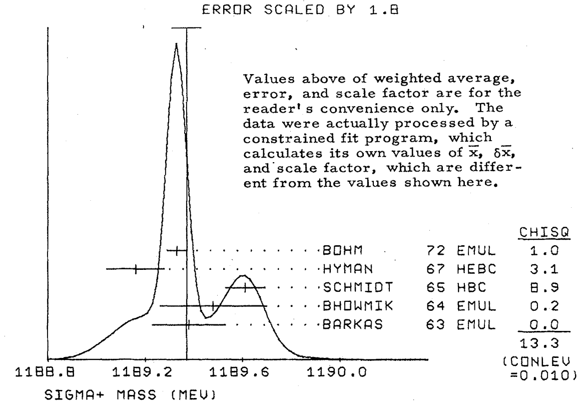
WEIGHTED AVERAGE = 1189.371 ± 0.060
ERROR SCALED BY 1.8

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                    19  SIGMA+ MEAN LIFE (UNITS 10**-10)

T                                          GLASER     58 RVUE
T      127     0.98      0.16      0.12  PUSCHEL    60 EMUL
T       41     0.82      0.34      0.20  EVANS      60 EMUL
T      117     0.85      0.14      0.11  FREDEN     60 EMUL
T       54     0.80      0.10      0.067 KAPLON     60 EMUL
T       23     0.76      0.22      0.14  CHIESA     61 EMUL
T       49     0.75      0.13      0.09  BERTHELOT  61 HLBC
T      140     0.82      0.10      0.08  BARKAS     61 EMUL
T      192     0.749     0.056     0.052 GRARD      62 HBC
T      456     0.765     0.04            HUMPHREY   62 HBC
T      203     0.84      0.12      0.08  BHOWMIK    64 EMUL
T      181     0.84      0.09            BALTAY     65 HBC                      6/66
T      900     0.76      0.03            CARAYAN    65 HBC                      6/66
T  C  1300     0.83      0.032           CHANG      66 HBC                      6/66
T   S  125    (0.86)    (0.15)           CHIEN      66 HBC  +   6.9 PBAR P      9/67
T   S  117    (1.10)    (0.24)           CHIEN      66 HBC  -   6.9 PBAR P,ANTI 9/67
T      381     0.80      0.07            COOK       66 OSPK                     7/66
T    10664     0.803     0.008           BARLOUTAU  69 HBC   K-P .4-1.2 GEV/C 11/69
T      20K     0.795     0.010           EISELE     70 HBC   K-P AT REST       2/71
T      526     0.83      0.04            BAKKER     71 DBC   K-N TO SIG+ 2PI- 10/71
T     5719     0.807     0.013           CONFORTO   76 HBC   K-P 1-1.4 GEV/C  11/77
T      30K     0.798     0.005           MARRAFFIN  80 HBC   K- P TO SIG+ PI-  2/80*
T  C    CHANG ERROR 0.018 RAISED BY US.  SEE 1970 EDITION, RMP 42,123(1970)  1/73
T   S   ERROR PURELY STATISTICAL
T           . . . . . . . . .
T   AVG        0.7997    0.0036    0.0036 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T   STUDENT    0.7996    0.0040    0.0039 AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    19  SIGMA+ MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM     381     1.5       1.1             COOK       66 OSPK                     7/66
MM      52     3.5       1.5             KOTELCHUC  67 EMUL  K-P AT 1.15BEV/C  8/67
MM      51     3.0       1.2             SULLIVAN   67 EMUL  PHOTOPRODUCTION   8/67
MM      69     3.5       1.2             COMBE      68 EMUL                    10/68
MM   29333     2.1       1.0             MAST       68 HBC   K-P AT .4 GEV/C   6/68
MM     955     2.67      0.97            ALLEY      71 OSPK  1.28 GEV/C PI+P  10/70
MM    2651     2.7       0.9             SAHA       73 HLBC  K-P.25TO.55GEV/C  6/73
MM  S 8503    (2.95)    (0.31)           DOBLE      77 HBC   K-P .46 GEV/C    12/77
MM   S 14K     2.30      0.14            SETTLES    79 HBC   K-P.42TO.50GEV/C 12/79*
MM   S  SETTLES 79 INCLUDES DOBLE 77 DATA.                                  12/79*
MM          . . . . . . . . .
MM  AVG        2.33      0.13     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
MM  STUDENT    2.33      0.14     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    19  SIGMA+ PARTIAL DECAY MODES

                                                       DECAY MASSES
P1       SIGMA+ INTO PROTON PIO                        938+ 134
P2       SIGMA+ INTO NEUTRON PI+                       939+ 139
P3       SIGMA+ INTO NEUTRON PI+ GAMMA                 939+ 139+   0
P4       SIGMA+ INTO LAMBDA E+ NEU                    1115+  .5+   0
P5       SIGMA+ INTO PROTON GAMMA                      938+   0
P6       SIGMA+ INTO NEUTRON MU+ NEUTRINO              939+ 105+   0
P7       SIGMA+ INTO NEUTRON E+ NEUTRINO               939+  .5+   0
P8       SIGMA+ INTO PROTON E+ E-                      938+  .5+  .5

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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

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             19  SIGMA+ BRANCHING RATIOS

R1      SIGMA+ INTO (NEUTRON PI+)/(NUCLEON PI)                 (P2)/(P1+P2)
R1      308    0.490     0.024          HUMPHREY  62 HBC
R1      534    0.46      0.02           CHANG     66 HBC                          6/66
R1     1331    0.488     0.010          BARLOUTAU 69 HBC     K-P .4-1.2 GEV/C 11/69
R1      537    0.484     0.015          TOVEE     71 EMUL                        12/71
R1     1861    0.488     0.008          NOWAK     78 HLBC                        7/79*
R1    M 10K    0.4828    0.0036         MARRAFFIN 80 HBC     K-P 420-500MEV/C  2/80*
R1    M  MARRAFFINO 80 GIVES BR TO (P PIO)/ALL.  WE QUOTE 1-BR.                  2/80*
R1               . . . . . . . . .
R1    AVG      0.4836    0.0030   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1    STUDENT  0.4837    0.0033   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R2      SIGMA+ INTO (NEUT PI+ GAM)/(PI+N) (UNITS 10**-3) (P3)/P2)
R2           (1.8)     ABOUT            BAZIN2    65 HBC     PI+ LT 116 MEV/C  8/67
R2      29     0.27      0.05           ANG       69 HBC     PI+ LT 110 MEV/C 11/68
R2     180     0.93      0.10           EBENHOH   73 HBC     PI+ LT 150 MEV/C  3/74

R3      SIGMA+ INTO (LAMBDA E+ NEU)/TOTAL (UNITS 10**-5) (P4)
R3   W    4    (3.3)     (1.7)          WILLIS    64 HBC     STOP. K-          9/66
R3   W                   EVENTS FROM THIS EXPERIMENT,INCLUDED IN EISELE1 69   11/69
R3        6    2.0       0.8            BARASH    67 HBC     STOP K-           8/67
R3        5    1.6       0.7            BALTAY    69 HBC     STOP K-          11/69
R3       10    2.9       1.0            EISELE1   69 HBC     STOP K-          10/69
R3               . . . . . . . . .
R3    AVG      2.02      0.47     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3    STUDENT  2.01      0.52     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R4      SIGMA+ INTO (P GAMMA)/(P PIO) (UNITS 10**-2)          (P5)/(P1)
R4        1    (0.068)OR LESS           CARRARA   64 HBC
R4       24    0.37      0.08           BAZIN     65 HBC
R4        4    (0.17)                   QUARENI   65 EMUL                          6/66
R4       45    0.21      0.03           ANG       69 HBC     STOP K-          10/69
R4       31    0.276     0.051          GERSHWIN  69 HBC                      10/69
R4               . . . . . . . . .
R4    AVG      0.240     0.035    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R4    STUDENT  0.239     0.030    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                  (SEE IDEOGRAM BELOW )
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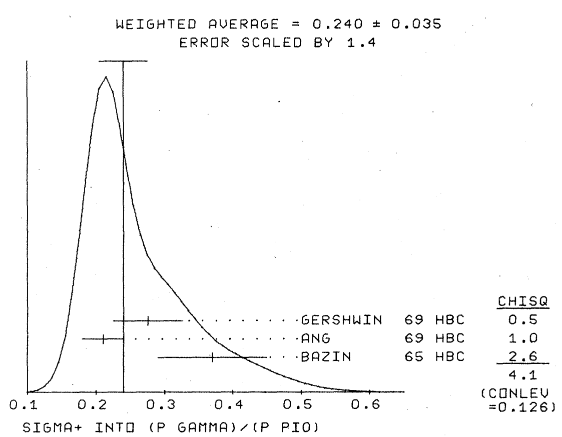


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R5      SIGMA+ INTO (N E+ NEU)/(N PI+) (UNITS 10**-5)     (P7)/(P2)
R5 EO     0    (16220)EFFECTIVE DENOM.  COURANT   64 HBC      SEE NOTE E      11/67
R5 EO     0    (2720)EFFECTIVE DENOM.   MURPHY    64 HBC      SEE NOTE E      11/67
R5 EO     1    (9690)EFFECTIVE DENOM.   NAUENBERG 64 HBC      SEE NOTE E       6/68
R5  O     0    (32436)EFFECTIVE DENOM.  BIERMAN   68 HBC                       6/68
R5 UA     0    (80400)EFFECTIVE DENOM.  EISELE2   69 HBC      STOP K-          6/68
R5 UO     1    (30000)EFFECTIVE DENOM.  NORTON    69 HBC                      11/69
R5  O    OLDER LOWER STATISTICS EXPTS. NOT INCLUDED IN AVERAGE.                2/76
R5 U      0    105000 EFFECTIVE DENOM.  SECHIZORN 73 HBC      STOP K-          2/76
R5 U A    0    111000 EFFECTIVE DENOM.  EBENHOH   74 HBC      STOP K-          1/76
R5 U                  EFFECTIVE DENOM.  CALCULATED BY US
R5 E                  EFFECTIVE DENOM.  TAKEN FROM EISELE 67                  11/67
R5    A  EISELE2 69 REPLACED BY BY EBENHOH 74.                                 1/76
R5               . . . . . . . . .
R5             1.1    OR LESS  CL=.90   OUR AVERAGE (2.3 EVTS)/(EFF.DNOM.SUM)  2/76
R5      NUMBER OF EVENTS INCREASED TO 2.3 FOR 90PC CONFIDENCE LEVEL            2/76

R6      SIGMA+ INTO (N MU+ NEU)/(PI+N) (UNITS 10**-5)     (P6)/(P2)
R6        1      (120)ANALYSED EVENTS   GALTIERI  62 EMUL     NO RATIO QUOTED 11/67
R6 E      0     10150 EFFECTIVE DENOM.  COURANT   64 HBC      SEE NOTE E      11/67
R6 E      0      1710 EFFECTIVE DENOM.  NAUENBERG 64 HBC      SEE NOTE E      11/67
R6 U      2     62000 EFFECTIVE DENOM.  EISELE2   69 HBC                       6/68
R6        0     33800 EFFECTIVE DENOM.  BAGGETT   69 HBC                      11/68
R6 E                  EFFECTIVE DENOM.  TAKEN FROM EISELE 67                  11/67
R6 U                  EFFECTIVE DENOM.  CALCULATED BY US
R6               . . . . . . . . .
R6             6.2    OR LESS  CL=.90   OUR AVERAGE (6.7 EVTS)/(EFF.DNOM.SUM)  2/76
R6      NUMBER OF EVENTS INCREASED TO 6.7 FOR 90PC CONFIDENCE LEVEL            2/76

R7      (SIGMA+ INTO LEPTONS)/(SIGMA- INTO LEPTONS)
R7        0    0.034 OR LESS            BAGGETT   67 HBC                       6/68
R7        1    0.08  OR LESS            NORTON    69 HBC                      10/69
R7               . . . . . . . . .
R7             0.043 OR LESS  CL=.90    OUR AVERAGE  USING R5 AND R6           2/76

R8      SIGMA+ INTO (PROTON E+ E-)/TOTAL (UNITS 10**-6)  (P8)
R8             7.0    OR LESS           ANG       69 HBC      STOP K-         10/69
R8    A  ANG 69 FOUND 3 E+E- EVENTS IN AGREEMENT WITH GAMMA CONVERSION OF
R8    A  PROTON GAMMA DECAY -LIMIT GIVEN HERE IS FOR NEUTRAL CURRENT

R9      (SIGMA+ INTO N MU+ NEU)/(SIGMA- INTO N MU- NEU)
R9      2  0.06          0.045     0.03   EISELE2   69 HBC  +- STOP K-        10/69
R9               . . . . . . . . .
R9             0.12  OR LESS  CL=.90    OUR AVERAGE  USING R6                  2/71

R10     (SIGMA+ INTO N E+ NEU)/(SIGMA- INTO N E- NEU)
R10 E     0    (0.03) OR LESS  CL=.90   EISELE2   69 HBC  +- STOP K-          10/69
R10 O     0    (0.12) OR LESS  CL=.95   COLE      71 HBC  +- STOP K-          10/71
R10 O   LOWER STATISTICS EXPERIMENT NOT INCLUDED IN AVERAGE                    2/76
R10       0     0.018 OR LESS  CL=.90   SECHIZORN 73 HBC  +- STOP K-,POISSON   8/73
R10  E    0     0.019 OR LESS  CL=.90   EBENHOH   74 HBC  +- STOP K-          12/75
R10  E  EISELE2 69 REPLACED BY EBENHOH 74.                                    12/75
R10              . . . . . . . . .
R10             0.009 OR LESS  CL=.90   OUR AVERAGE  USING R5                  2/76

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             19  SIGMA+ DECAY PARAMETERS

        RELATED TEXT SECTION VI D AND APPENDIX III

A+0     ALPHA+/ALPHAO FOR SIGMA+ (SIG+ TO PI+ N)/(SIG+ TO PIO P)
A+0          (+0.04)   (0.11)           CORK      60 CNTR    SIG+ FROM PI+P
A+0          (+0.20)   (0.24)           TRIPP     62 HBC     REPLAC.BY BANGER
A+0 O 3500   (-.014)   (0.052)          BANGERTER 66 HBC     SIG+ FROM K-P     9/66
A+0 O 2600   (-.047)   (.07)            BERLEY    66 HBC     SIG+ FROM K-P     9/66
A+0    20K   (-0.104)  (0.028)          REUCROFT  77 HBC REPL.BY MARRAFFINO80  6/77
A+0    23K   -0.073    0.021            MARRAFFIN 80 HBC     K- P TO SIG+ PI-  2/80*
A+0 O        OLD RESULTS, HAVE BEEN REPLACED. SEE BELOW.
A+0              . . . . . . . . .
A+0 FIT      -0.069    0.013   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)   2/80*

A+      ALPHA+ FOR SIGMA+ (SIG+ TO PI+ N)
A+    35000    0.069     0.017          BANGERTER 69 HBC     K-P AT 400 MEV/C 11/69
A+     4101    0.037     0.049          BERLEY    70 HBC                      12/70
A+               . . . . . . . . .
A+    AVG      0.066     0.016    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A+    STUDENT  0.066     0.017    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
A+    FIT      0.068     0.013  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*

AO      ALPHAO FOR SIGMA+ (SIG+ INTO PIO PROTON)
AO           -0.80     0.16             BEALL     62 CNTR
AO           (-0.90)   (0.25)           TRIPP     62 HBC     REPLAC. BY BANGE
AO    O 5200 (-0.986)  (0.072)          BANGERTER 66 HBC     K-P TO SIG+ PI-   7/66
AO     32000 -0.999    0.022            BANGERTER 69 HBC                      10/69
AO H  1335   -0.98     0.05      0.02   HARRIS    70 OSPK    PI+P TO SIG+ K+   5/70
AO       16K -0.940    0.045            BELLAMY   72 ASPK    PI+P TO SIG+ K+  11/72
AO L  1259   -0.945    0.055     0.042  LIPMAN    73 OSPK    PI+P TO SIG +     7/73
AO L     DECAY PROTONS SCATTERED OFF ALUMINUM.                                 7/73
AO H     DECAY PROTONS SCATTERED OFF CARBON.
AO               . . . . . . . . .
AO    AVG      -0.979    0.016    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AO    STUDENT  -0.979    0.018    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
AO    FIT      -0.979    0.016  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*

F+      PHI+ ANGLE (SIG+ INTO N PI)  SIN(PHI)/COS(PHI)=BETA/GAMMA  (DEGREE)
F+    O  370 (180.)     (30.)           BERLEY    66 HBC     NEUTRON RESCATT.  9/66
F+       560  143.       29.            BANGERT1  69 HBC                      10/69
F+     C1054  184.       24.            BERLEY    70 HBC     K-P AT 400 MEV/C 11/69
F+     C  CHANGED FROM 176 TO 184 TO AGREE WITH SIGN CONVENTION.
F+               . . . . . . . . .
F+    AVG      167.3     20.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
F+    STUDENT  167.5     21.2     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

AG      ALPHAG FOR SIGMA+ (SIG+ INTO PROTON GAMMA)
AG       61    -1.03     0.52      0.42  GERSHWIN  69 HBC     K-P TO SIG PI    11/69

FO      PHIO ANGLE (SIG+ INTO PIO PROTON) SIN(PHI)/COS(PHI)=BETA/GAMMA (DEG)
FO H          22.0      90.0            HARRIS    70 OSPK PI+P TO SIG+ K+      5/70
FO L   1259   38.1      35.7     37.1   LIPMAN    73 OSPK    PI+P TO SIG+K+    7/73
FO L     DECAY PROTON SCATTERED OFF ALUMINUM.                                  7/73
FO H     DECAY PROTONS SCATTERED OFF CARBON.
FO               . . . . . . . . .
FO    AVG      35.8      33.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
FO    STUDENT  35.8      36.4     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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REFERENCES FOR SIGMA+


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CORK      60 PR 120 1000        CORK,KERTH,WENZEL,CRONIN,COOL(LRL+PRIN+BNL)
EVANS     60 NC 15 873          BRIST+BRUSS+IAS-U.COL-DUBLIN+LCN+MILAN+PAD
FREDEN    60 NC 16 611          S FREDEN,H KORNBLUM,R WHITE            (LRL)
KAPLON    60 ANP 9 139          M KAPLON,A MELISSINOS,YAMANOUCHI      (ROCH)
PUSCHEL   60 NP 20 254          W PUSCHEL                 (MAX PLANCK INST)

BARKAS    61 PR 124 1209        BARKAS,DYER,MASON,NICHOLS,SMITH        (LRL)
BERTHELO  61 NC 21 693          BERTHELOT,DAUDIN,GOUSSU +     (SACLAY+ORSAY)
CHIESA    61 NC 19 1171         CHIESA,QUASSIATI,RINAUDC       (INFN-TURIN)

BEALL     62 PR 8 75            BEALL,CORK,KEEFE,MURPHY,WENZEL         (LRL)
GRARD     62 PR 127 607         F GRARD,G A SMITH                      (LRL)
GALTIERI  62 PRL 9 26           GALTIERI,BARKAS,HECKMAN,PATRICK,SMITH  (LRL)
HUMPHREY  62 PR 127 1305        W E HUMPHREY,R R ROSS                  (LRL)
TRIPP     62 PRL 9 66           R D TRIPP,M B WATSON,M FERRO-LUZZI     (LRL)

BARKAS    63 PRL 11 26          W H BARKAS,J N DYER,H H HECKMANN       (LRL)
     ALSO 61 UCRL 9450          JOHN DYER (THESIS, BERKELEY)           (LRL)

BHOWMIK   64 NP 53 22           B BHOWMIK,P JAIN,P MATHUR,LAKSHMI    (DELHI)
CARRARA   64 PL 12 72           CARRARA,CRESTI,GRIGOLETTO,PERUZZO+ (PADOVA)
COURANT   64 PR 136 B 1791      COURANT,FILTHUTH+    (CERN+HEID+UMD+NRL+BNL)
MURPHY    64 PR 134 B 188       C THORNTON MURPHY                (WISCONSIN)
NAUENBER  64 PRL 12 679         NAUENBERG,MARATECK,+        (COLU+RUTG+PRIN)
WILLIS    64 PRL 13 291         WILLIS,COURANT,ENGELMAN+(BNL,CERN,HEID,UMD)

BALTAY    65 PR 140 B 1027      BALTAY,SANDWEISS,CULWICK,KOPP +   (YALE+BNL)
BAZIN     65 PRL 14 154         BAZIN,BLUMENFELD,NAUENBERG +     (PRIN+COLU)
BAZIN2    65 PR 140 B1358       BAZIN,PLANO,SCHMIDT+          (PRIN,RUTG,COLU)
CARAYAN   65 PR 138 B 433       CARAYANNOPOULOS,TAUTFEST,WILLMANN  (PURDUE)
QUARENI   65 NC 40 A 928        QUARENI,CARTACCI +      (BGNA,FIRZ,GENO,PARMA)
SCHMIDT   65 PR 140 B 1328      P SCHMIDT                         (COLUMBIA)

BANGERTE  66 PRL  17 495        BANGERTER,GALTIERI,BERGE,MURRAY+       (LRL)
BERLEY    66 PRL 17 1071        +HERZBACH,KOFLER,YAMAMOTO + (BNL+MASA+YALE)
CHANG     66 PR  151  1081      CHUNG YUN CHANG                   (COLUMBIA)
     ALSO 65 NEVIS 145  THESIS  CHUNG YUN CHANG                   (COLUMBIA)
CHIEN     66 PR  152  1171      +LACH,SANDWEISS,TAFT,YEH,OREN +   (YALE+BNL)
COOK      66 PRL  17  223       V COOK,EWART,MASEK,ORR,PLATNER (WASHINGTON)

BAGGETT   67 PRL 19 1458        BAGGETT,DAY,GLASSER,KEHOE,KNOP+   (MARYLAND)
     ALSO 68 VIENNA ABS. 374    BAGGETT,KEHOE                     (MARYLAND)
     ALSO 68 PRIVATE COMM.      N. BAGGETT                        (MARYLAND)

BARASH    67 PRL 19  181        BARASH,DAY,GLASSER,KEHOE,KNOP +   (MARYLAND)
EISELE    67 ZPHYS 205 409      +ENGELMANN,FILTHUTH,FOLISH,HEPP+      (HEID)
HYMAN     67 PL 25 B 376        +LOKEN,PEWITT,MCKENZIE,+     (ANL+CARN+NWES)
KOTELCHU  67 PRL 18 1166        KOTELCHUCK,GOZA,SULLIVAN,ROSS  (VANDERBILT)
SULLIVAN  67 PRL 18 1163        SULLIVAN,MCINTURFF,KOTELCHUCH  (VANDERBILT)
     ALSO 64 PRL 13 246         A D MCINTURFF,C E ROOS         (VANDERBILT)
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Stable Particles

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Data Card Listings

For notation, see key at front of Listings.

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BIERMAN  68 PRL 20 1459          BIERMAN,KOUNOSU,NAUENBERG +     (PRINCETON)
COMBE    68 NC 57A 54            CERN-BRISTOL-LAUSANNE-MUNICH-ROME-COLLABOR
MAST     68 PRL 20 1312          MAST,GERSHWIN,ALSTON-GARNJOST +       (LRL)

ANG      69 ZPHYS 228 151        +EBENHOH,EISELE,ENGELMANN,FILTHUTH+  (HEID)
BAGGETT  69 MDDP-TR-973          N V BAGGETT (THESIS)                  (UMD)
BALTAY   69 PRL 22 615           BALTAY,FRANZINI,NEWMAN,NORTON+  (COLU,STON)
BANGERTE 69 UCRL-19244           ROGER ODELL BANGERTER (THESIS)        (LRL)
BANGERT1 69 PR 187 1821          BANGERTER,GARNJOST,GALTIERI,GERSHWIN+ (LRL)

BARLOUTA 69 NP B14 153           BARLOUTAUD,BELLEFON,GRANET+(SACL+CERN+HEID)
EISELE1  69 ZPHYS 221 1          +ENGELMANN,FILTHUTH,FOHLISCH,HEPP+   (HEID)
EISELE2  69 ZPHYS 221 401        +ENGELMANN,FILTHUTH,FOHLISCH,HEPP+   (HEID)
GERSHWIN 69 PR 188 2077          +ALSTON-GARNJOST,BANGERTER +          (LRL)
   ALSO     UCRL 19246 THESIS LAWRENCE K GERSHWIN                      (LRL)
NORTON   69 NEVIS 175 (THESIS) HERBERT NORTCN                     (COLUMBIA)

BERLEY   70 PR D1 2015           +YAMIN,HERTZBACH,KOFLER +  (BNL,MASA,YALE)
EISELE   70 ZPHY 238 372         +FILTHUTH,HEPP,PRESSER,ZECH   (HEIDELBERG)
HARRIS   70 PRL 24 165           +OVERSETH,PONDROM,DETTMANN     (MICH,WISC)

ALLEY    71 PR  D3  75           +BENBROOK,COOK,GLASS,GREEN,HAGUE +   (WASH)
BAKKER   71 LNC 1 37             +,SABRE COLLAB.  (ZEEM+SACL+BGNA+REHO+EPOL)
COLE     71 PR D4 631            +LEE-FRANZINI,LOVELESS,BALTAY+  (STON,COLU)
TOVEE    71 NP B33 493           LOUC,BELGRADE,BERL,BRUX,DUBLIN,WARS COLLAB
BELLAMY  72 PL 39B 299           +ANDERSON,CRAWFORD,OSMON+  (LOWC+RHEL+SUSS)
BOHM     72 NP B48 1             BERLIN+BELGRADE+BRUX+DUBLIN+LOUC+WARSAW
   ALSO 73 IIHE-73.2 NOV         BRUSSELS BULLETIN, SAME COLLABORATION

EBENHOH  73 ZPHY 264 413         +EISELE,FILTHUTH,HEPP,LEITNER,THOUW+ (HEID)
LIPMAN   73 PL 43B 89            +UTO,WALKER,MCNTGOMERY+     (RHEL+SUSS+LOWC)
SAHA     73 PR D7 3295           +FETKOVICH,HEINTZELMAN,MELTZER +     (CARN)
SECHIZOR 73 PR D8 12             B.SECHI-ZORN,G.SNOW                   (UMD)

EBENHOH  74 ZPHY 266 367         +EISELE,ENGELMANN,FILTHUTH,HEPP +    (HEID)
CONFORTO 76 NP B105 189          +GOPAL,KALMUS,LITCHFIELD,ROSS + (RHEL+LOIC)
DOBLE    77 PL 67B 483           +GOTTSTEIN,HANSL,HERYNEK+  (MPIM+BOHR+VAND)
REUCROFT 77 PR D15 5             +ROOS,WATERS,WEBSTER,HANSL +    (VAND+MPIM)
NOWAK    78 NP B139 61           +ARMSTRONG,DAVIS+      (LOUC+BELG+DURH+WARS)

SETTLES  79 PR D20 2154          +MANZ,MATT,HANSL,HERYNEK,DOBLE+ (MPIM+VAND)
MARRAFFI 80 PR D (TO BE PUB.) MARRAFFINO,REUCROFT,ROOS,WATERS+(VAND+MPIM)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

GLASER   58 CERN CCNF 270        GLASER,GOOD,MORRISON             (MICH+LRL)

         QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

TRIPP    62 PRL 8 175            R TRIPP,M WATSON,M FERRO-LUZZI      (LRL) P
ALFF     63 SIENA CONF 1 205  ALFF,NAUENBERG,KIRSCH,+      (COLU+RUTG+BNL)
   ALSO 65 PR 137 B 1105         ALFF,GELFAND,BRUGGER,BERLEY+(COLU+RUTG+BNL)
COURANT  63 SIENA CONF 1 73   COURANT,FILTHUTH,BURNSTEIN,DAY+  (CERN+UMD)

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                 20  SIGMA-(1198,JP=1/2+) I=1

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                 20  SIGMA- MASS (MEV)

M    N   SEE NCTE PRECEDING LAMBDA MASS LISTINGS

M      3000 1197.43     0.08            SCHMIDT   65 HBC  SEE NOTE N        3/74
M           1197.24     0.15            DUGAN     75 CNTR   EXOTIC ATOMS   12/79*
M              . . . . . . . . . . .
M    AVG    1197.388    0.079  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
M    STUDENT1197.390    0.080  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M    FIT    1197.34     0.05  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*

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                 20  (SIGMA-) - (SIGMA+) MASS DIFFERENCE (MEV)

D        87    8.25     0.40            BARKAS    63 EMUL
D      2500    8.25     0.25            DOSCH     65 HBC
D        86    7.91     0.23            BOHM      72 EMUL                   1/73
D              . . . . . . . . . . .
D    AVG       8.09     0.16   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D    STUDENT   8.10     0.18   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
D  , FIT       7.97     0.07  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)  2/80*

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                 20  (SIGMA-) - (LAMBDA) MASS DIFFERENCE (MEV)

DL   N   SEE NCTE PRECEDING LAMBDA MASS LISTINGS.

DL            81.70     0.19            BURNSTEIN 64 HBC                    9/66
DL       85   81.80     0.13            SCHMIDT   65 HBC  SEE NOTE N        3/74
DL     2279   81.64     0.09            HEPP      68 HBC                    8/68
DL             . . . . . . . . . . .
DL   AVG      81.693    0.069  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
DL   STUDENT  81.692    0.077  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
DL   FIT      81.740    0.052 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*

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                 20  SIGMA- MEAN LIFE (UNITS 10**-10)

T             1.67      0.40      0.28  BROWN      58 HLBC
T             1.89      0.33      0.25  EISLER     58 HLBC
T        45   1.35      0.32      0.17  CHIESA     61 EMUL
T        41   1.75      0.39      0.30  EARKAS     61 EMUL
T      1208   1.58      0.06      0.06  HUMPHREY   62 HBC    STOP. K-
T  C   3267   1.666     0.075           CHANG      66 HBC    STOP. K-          6/66
T   S    61  (2.08)    (0.22)           CHIEN      66 HBC  -  6.9 PBAR P       9/67
T   S    64  (1.46)    (0.31)           CHIEN      66 HBC  +  6.9 PBAR P,ANTI  9/67
T       506   1.38      0.07            WHITESIDE  68 HBC    STOP. K-          6/68
T     10253   1.472     0.016           BARLOUTAU  69 HBC    K-P .4-1.2 GEV/C 11/69
T       .1M   1.485     0.022           EISELE     70 HBC    K-P AT REST       2/71
T      1383   1.42      0.05            BAKKER     71 DBC    K-N TO SIG- 2PI  10/71
T             1.41      0.09      0.08  TOVEE      71 EMUL                    12/71
T      2400   1.463     0.039           ROBERTSON  72 HBC    K-P .25 GEV/C     3/74
T      8437   1.49      0.03            CONFORTO   76 HBC    K-P 1-1.4 GEV/C  11/77
T       16K   1.480     0.014           MARRAFFIN  80 HBC    K- P TO SIG- PI+  2/80*
T  C   CHANG ERROR 0.018 RAISED BY US.  SEE 1970 EDITION, RMP 42,123(1970)  1/73
T   S   ERROR PURELY STATISTICAL.
T              . . . . . . . . . . .
T    AVG      1.482     0.011     0.011  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.3)
T    STUDENT  1.4806    0.0093    0.0092 AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )
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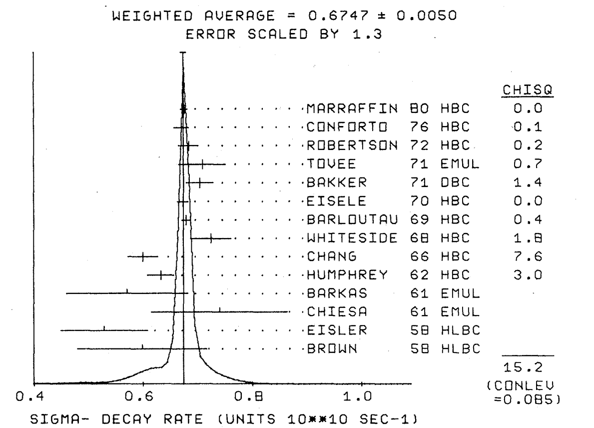


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                 20  SIGMA- MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM   R      BTWN -1.6 AND +0.8         FOX       73 CNTR   SIG-ATOM FINE ST  3/74
MM    R        -1.48      0.37         ROBERTS   74 CNTR   SIG-ATOM FINE ST 12/75
MM    D        -1.40      0.41    0.28 DUGAN     75 CNTR   SIG-ATOM FINE ST 12/79*
MM   D         (0.65)    (0.28)  (0.40) DUGAN    75 CNTR   SIG-ATOM FINE ST 12/79*
MM      28K    -0.71      1.25         HANSL     78 HBC    K-P-->SIG- PI+    7/79*
MM    R  ROBERTS 74 INCLUDES DATA FROM FOX 73.                              12/75
MM    D  DUGAN 75 NEGATIVE VALUE AVERAGED SINCE IT AGREES WITH ROBERTS 74.  12/79*
MM            . . . . . . . . . . .
MM   AVG       -1.41      0.25    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
MM   STUDENT   -1.41      0.27    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                 20  SIGMA- PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      SIGMA- INTO NEUTRON PI-                         939+ 139
P2      SIGMA- INTO NEUTRON PI- GAMMA                   939+ 139+    0
P3      SIGMA- INTO NEUTRON MU- NEUTRINO                939+ 105+    0
P4      SIGMA- INTO NEUTRON E- NEUTRINO                 939+  .5+    0
P5      SIGMA- INTO LAMBDA E- NEUTRINO                 1115+  .5+    0

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                 20  SIGMA- BRANCHING RATIOS

R1      SIGMA- INTO (N MU- NEU)/(N PI-) (UNITS 10**-3)    (P3)/(P1)
R1       22    0.66     0.15           COURANT   64 HBC
R1       11    0.56     0.20           BAZIN     65 HBC     FROM STOP. K-    6/66
R1       56    0.43     0.09           BAGGETT   69 HBC    STOP. K-         10/69
R1       72    0.43     0.06           ANG 1     69 HBC    STOP K-          10/69
R1       13    0.38     0.11           COLE      71 HBC    STOP K-          10/71
R1            . . . . . . . . . . .
R1   AVG        0.447    0.043   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1   STUDENT    0.445    0.047   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R2      SIGMA- INTO (N E- NEU)/(N PI-) (UNITS 10**-3)    (P4)/(P1)
R2        9    1.0      0.4      0.3   MURPHY    64 HLBC
R2       16    1.37     0.34           NAUENBERG 64 HBC
R2       16    1.15     0.4            MILLER    64 FBC
R2       31    1.4      0.3            COURANT   64 HBC
R2      180    1.11     0.09           BIERMAN   68 HBC                      6/68
R2   A  331   (1.02)   (0.08)          ANG 1     69 HBC    STOP K-          10/69
R2       57    0.97     0.15           COLE      71 HBC    STOP K-          10/71
R2      455    1.05     0.07           SECHIZORN 73 HBC    STOP K-           8/73
R2    A 601    1.09     0.06           EBENHOH   74 HBC    STOP K-           1/76
R2    A  ANG 1 69 REPLACED BY EBENHOH 74.                                    1/76
R2            . . . . . . . . . . .
R2   AVG        1.082    0.038   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2   STUDENT    1.082    0.041   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R3      SIGMA- INTO (LAMBDA E- NEU)/(N PI-) (UNITS 10**-4)
R3                                                (P5)/(P1)
R3       11    0.75     0.28           COURANT   64 HBC    STOP. K-
R3       35    0.64     0.12           BARASH    67 HBC    STOP K-           8/67
R3       31    0.69     0.12           EISELE1   69 HBC    STOP K-          10/69
R3       31    0.52     0.09           BALTAY    69 HBC    STOP K-           4/69
R3   H  122   (0.60)   (0.11)          HERBERT   78 ASPK   HYPERON BEAM      6/78*
R3    H 115    0.63     0.10           THOMPSON  80 ASPK   HYPERON BEAM      2/80*
R3   H   HERBERT 78 REPLACED BY THOMPSON 80.
R3            . . . . . . . . . . .
R3   AVG        0.611    0.052   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3   STUDENT    0.613    0.058   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R4      SIGMA- INTO (N PI- GAMMA)/(N PI-) (UNITS 10**-3) (P2)/(P1)
R4          (1.1)APPROXIM.             BAZIN     65 HBC    PI- LT 166 MEV/C  8/67
R4       23    0.10      .02           ANG 2     69 HBC    PI- LT 110 MEV/C 10/69
R4      292    0.46     0.06           EBENHOH   73 HBC    PI+ LT 150 MEV/C  3/74

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                 20  SIGMA- DECAY PARAMETERS

      RELATED TEXT SECTION VI D AND APPENDIX III

A-      ALPHA SIGMA-
A-          (-0.16)    (0.21)          TRIPP     62 HBC    REPL.BY BANGERTE
A-   O 6500 (-0.010)   (0.043)         BANGERTER 66 HBC    K-P TO SIG- PI+   7/66
A-   O 6068 (-0.104)   (0.04)          BERLEY    67 HBC    K-P TO SIG- PI+  11/67
A-    51000  -0.071     0.012          BANGERTER 69 HBC                     10/69
A-   B 5978 (-0.134)   (0.034)         BERLEY    70 HBC    K-P AT 400 MEV/C  2/71
A-    60000  -0.067     0.011          BOGERT    70 HBC    K-P AT 400 MEV/C 12/70
A-      28K  -0.062     0.024          HANSL     78 HBC    K-P-->SIG- PI+    7/79*
A-   O   OLD RESULTS.  HAVE BEEN REPLACED.
A-   B   BERLEY 70 REPLACED BY BOGERT 70                                     2/71
A-            . . . . . . . . . . .
A-   AVG       -0.0681   0.0077  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A-   STUDENT   -0.0681   0.0082  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

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F-      PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA)  (DEGREES)
F-   O 1006 (+22.)   (30.)            BERLEY    67 HBC    K-P TO SIG- PI+  11/67
F-     1385   14.      19.            BANGERT1  69 HBC                     10/69
F-    C1092  + 5.     23.             BERLEY    70 HBC    NEUTRON RESCATT. 11/69
F-   C   CHANGED FROM -5 TO +5 TO AGREE WITH SIGN CONVENTION
F-           . . . . . . . . .
F-   AVG       10.3     14.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
F-   STUDENT   10.4     15.8     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

AV      GV/GA FOR SIGMA TO LAMBDA BETA DECAY (TEXT SEC VI D.1 FOR SIGN CONV)
AV       PREDICTED TO BE ZERO BY CONSERVED VECTOR CURRENT THEORY
AV   FB  45   (0.31)   (0.30)          BARASH    67 HBC                    11/67
AV   FS  51   (0.7)    (0.4)           BALTAY    69 HBC    USING SIG+-      4/69
AV   FS  81  (+0.22)   (0.28)          EISELE1   69 HBC                    10/68
AV F S 186     0.37     0.20           FRANZINI  72 HBC    USING SIG+-      1/73
AV   T  55    -0.17     0.35           TANENBAUM 75 SPEC                   12/75
AV     115    -0.32     0.30           THOMPSON  80 ASPK   HYPERON BEAM     2/80*
AV   B  BARASH 67 MEASURED ABSOLUTE VALUE.
AV   S  SIGN CHANGED TO AGREE WITH OUR CONVENTION.
AV F    FRANZINI 72 INCLUDES EVENTS OF BARASH 67, EISELE1 69, BALTAY 69.     1/73
AV   T  WE QUOTE TANENBAUM 75 WHICH ASSUMES CVC WK MAG TERM.                1/76
AV           . . . . . . . . .
AV   AVG        0.10     0.22    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
AV   STUDENT    0.09     0.19    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )
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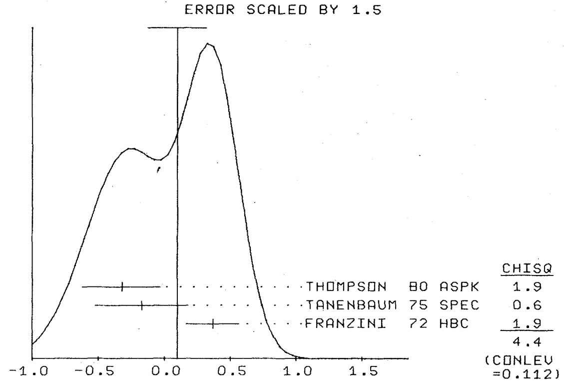
WEIGHTED AVERAGE = 0.10 ± 0.22
ERROR SCALED BY 1.5



GV/GA FOR SIGMA- TO LAMBDA BETA DECAY

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AV1     GA/GV FOR SIGMA TO NEUTRON BETA DECAY(TEXT SEC VI D.1 FOR SIGN CONV)
AV1      57   (0.05)   (0.23)   (0.32) GERSHWIN  68 HBC  REPLACED BY GER.69   6/68
AV1      61   +0.19     0.20     0.17  GERSHWIN  69 HBC  POLARIZED SIGMAS    10/69
AV1      63   -0.33     0.30     0.85  BOGERT    70 HBC  K-P AT 400 MEV/C    10/70
AV1      43   -0.4      0.52     1.5   ELLIS     72 ASPK   POLARIZED SIGMAS 10/71
AV1 E        (+0.10)   (0.11)          ELLIS     72 RVUE   SUM LIKEL.(+SOL) 10/71
AV1 E        (-0.27)   (0.13)   (0.17) ELLIS     72 RVUE   SUM LIKEL.(-SOL) 10/71
AV1 E   ELLIS 72 HAS COMBINED THE MAXIMUM LIKELIHOODS OF COLLERAINE 69,       3/72
AV1 E   EISELE2 69, GERSHWIN 69, ELLIS 72, AND GETS TWO POSSIBLE VALUES.      3/72
AV1          . . . . . . . . .
AV1 AVG        0.13     0.17     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AV1 STUDENT    0.13     0.19     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

AV2     ABSOLUTE VALUE OF GA/GV FOR SIGMA TO NEUTRON BETA DECAY
AV2      49    0.23     0.16           COLLERAIN 69 HBC    NEUTRON SCATTER  10/69
AV2      33    0.37     0.26     0.19  EISELE2   69 HBC    NEUTRON SCATTER .10/69
AV2      36    0.29     0.28     0.29  BALTAY    72 HBC    NEUTRON SCATTER   6/72
AV2    3507    0.435    0.035          TANENBAU  74 ASPK                    10/74
AV2     519    0.17     0.07     0.09  DECAMP    77 ELEC   H.E.HYPERON BEAM 11/77
AV2          . . . . . . . . .
AV2 AVG        0.385    0.070    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
AV2 STUDENT    0.396    0.041    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )
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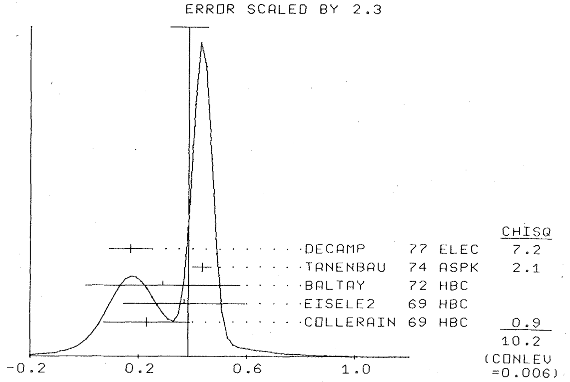
WEIGHTED AVERAGE = 0.385 ± 0.070
ERROR SCALED BY 2.3



ABS(GA/GV) FOR SIGMA TO N BETA DECAY

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                              REFERENCES FOR SIGMA-

BROWN     58 CERN CONF 270      BROWN,GLASER,GRAVES,PERL,CRONIN +      (MICH)
EISLER    58 NC SER10 10 150    EISLER,BASSI,CONVERSI+ (COLU,BNL,BGNA,PISA)

BARKAS    61 PR 124 1209        BARKAS,DYER,MASON,NICKOLS,SMITH          (LRL)
CHIESA    61 NC 19 1171         A M CHIESA,B QUASSIATI,G RINAUDO       (TURIN)
HUMPHREY  62 PR 127 1305        W E HUMPHREY,R R ROSS                    (LRL)
TRIPP     62 PRL 9 66           R D TRIPP,M WATSON,M FERRO-LUZZI         (LRL)

BARKAS    63 PRL 11 26          W H BARKAS,J N DYER,H H HECKMAN          (LRL)
BURNSTEI  64 PRL 13 66          BURNSTEIN,DAY,KEHOE,SECHI ZORN,SNOW      (UMD)
COURANT   64 PR 136 B 1791      COURANT,FILTHUTH+    (CERN+HEID+UMD+NRL+BNL)
MILLER    64 PL 11 262          MILLER,STANNARD,BEZAGUET+  (LOUC,EPOL+BERG)
MURPHY    64 PR 134 B 188       C THORNTON MURPHY                  (WISCONSIN)
NAUENBER  64 PRL 12 679         NAUENBERG,SCHMIDT,MARATECK+(COLU+RUTG+PRIN)

BAZIN     65 PR 140 B 1358      BAZIN,PLANO,SCHMIDT +          (PRIN+RUTG+COLU)
DOSCH     65 PL 14 239          DOSCH,ENGELMANN,FILTHUTH,HEPP,KLUGE+ (HEID)
    ALSO  66 PR  151  1081      CHUNG YUN CHANG                     (COLUMBIA)
SCHMIDT   65 PR 140 B 1328      P SCHMIDT                           (COLUMBIA)
BANGERTE  66 PRL  17  495       BANGERTER,GALTIERI,BERGE,MURRAY+         (LRL)
CHANG     66 PR  151 1081       CHUNG YUN CHANG                     (COLUMBIA)
CHIEN     66 PR  152  1171      +LACH,SANDWEISS,TAFT,YEH,OREN +    (YALE+BNL)

BARASH    67 PRL 19  181        BARASH,DAY,GLASSER,KEHOE,KNOP +   (MARYLAND)
BERLEY    67 PRL  19  979       BERLEY,HERTZBACH,KOFLER +    (BNL,MASA,YALE)
BIERMAN   68 PRL 20 1459        BIERMAN,KOUNOSU,NAUENBERG +      (PRINCETON)
GERSHWIN  68 PRL 20 1270        GERSHWIN,ALSTON-GARNJOST,BANGERTER+      (LRL)
HEPP      68 ZPHY 214 71        V.HEPP,H. SCHLEICH                (HEIDELBERG)
WHITESID  68 NC  54A  537       H. WHITESIDE,J. GCLLUB               (OBERLIN)

ANG 1     69 ZPHY 223 103       ANG,EISELE,ENGELMANN,FILTHUTH +         (HEID)
ANG 2     69 ZPHY 228 151       +EBENHOR,EISELE,ENGELMANN,FILTHUTH+     (HEID)
BAGGETT   69 PRL 23 249         BAGGETT,KEHOE,SNOW              (UNIV MARYLAND)
BALTAY    69 PRL 22 615         BALTAY,FRANZINI,NEWMAN,NORTON+    (COLU,STON)
BANGERTE  69 UCRL-19244         ROGER ODELL BANGERTER (THESIS)           (LRL)
BANGERT1  69 PR 187 1821        BANGERTER,GARNJOST,GALTIERI,GERSHWIN+ (LRL)

BARLOUTA  69 NP B14 153         BARLOUTAUD,BELLEFON,GRANET+(SACL+CERN+HEID)
COLLERAI  69 PRL 23 198         COLLERAINE,DAY,GLASSER,KNOP+(UNIV MARYLAND)
EISELE1   69 ZPHY 221 1         +ENGELMANN,FILTHUTH,FOHLISCH,HEPP+      (HEID)
EISELE2   69 ZPHY 223 487       EISELE,ENGELMANN,FILTHUTH,FOHLISCH+     (HEID)
GERSHWIN  69 UCRL-19246         LAWRENCE KENNETH GERSHWIN (THESIS)       (LRL)

BERLEY    70 PR D1 2015         +YAMIN,HERTZBACH,KOFLER +    (BNL,MASA,YALE)
BOGERT    70 PR D2 6            +LUCAS,TAFT,WILLIS,BERLEY + (BNL,MASA,YALE)
EISELE    70 ZPHY 238 372       +FILTHUTH,HEPP,PRESSER,ZECH       (HEIDELBERG)

BAKKER    71 LNC 1 37           +,SABRE COLLAB.  (ZEEM+SACL+BGNA+REHO+EPOL)
COLE      71 PR D4 631          +LEE-FRANZINI,LOVELESS,BALTAY+    (STON,COLU)
    ALSO  69 NEVIS-175 THESIS   HERBERT NORTON                      (COLUMBIA)
TOVEE     71 NP B33 493         LOUC,BELGRADE,BERL,BRUX,DUBLIN,WARS COLLAB

BALTAY    72 PR D5 1569         +FEINMAN,FRANZINI,NEWMAN,YEH+     (COLU+STON)
BOHM      72 NP B48 1           BERLIN+BELGRADE+BRUX+DUBLIN+LOUC+WARSAW
ELLIS     72 NP B39 77          OXF+AERE+RHEL+LOQM+LYON+NWES+ITEP COLLABOR
FRANZINI  72 PR D6 2417         COLUMBIA+HEIDELBERG+MARYLAND+STONY BROOK
ROBERTSO  72 THESIS             R.M.ROBERTSON                            (IIT)

EBENHOH   73 ZPHY 264 413       +EISELE,FILTHUTH,HEPP,LEITNER,THOUW+ (HEID)
FOX       73 PRL 31 1084        +LAM,BARNES,EISENSTEIN+ (BNL+VPI+WILL+WYOM)
SECHIZOR  73 PR D8 12           B.SECHI-ZORN,G.SNOW                      (UMD)

EBENHOH   74 ZPHY 266 367       +EISELE,ENGELMANN,FILTHUTH,HEPP +       (HEID)
ROBERTS   74 PRL 32 1265        WILL+VPI+CARN+WYOM+CIT COLLABORATION
    ALSO  74 PRL 33 122         ERRATUM TO ROBERTS 74
    ALSO  75 PR D12 1232        ROBERTS,COX +  (WILL+VPI+CARN+WYOM+CIT+BNL)
TANENBAU  74 PRL 33 175         TANENBAUM,HUNGERBUEHLER +    (YALE+FNAL+BNL)
    ALSO  75 TANENBAUM

DUGAN     75 NP A254 396        +ASANO,CHEN,CHENG,HU,LIDOFSKY+   (COLU+YALE)
TANENBAU  75 PR D12 1871        TANENBAUM,HUNGERBUEHLER +    (YALE+FNAL+BNL)
CONFORTO  76 NP B105 189        +GOPAL,KALMUS,LITCHFIELD,ROSS + (RHEL+LOIC)
DECAMP    77 PL 66B 295         +BADIER,BLAND,CHOLLET,GAILLARD+ (LALO+EPOL)
HANSL     78 NP B132 45         +MANZ,MATT,REUCROFT,SETTLES +    (MPIM+VAND)
HERBERT   78 PRL 40 1230        +CLELAND,COOPER,DRIS,ENGELS +     (PITT+BNL)
MARRAFFI  80 PR D (TO BE PUB.) MARRAFFINO,REUCROFT,ROOS,WATERS+(VAND+MPIM)
THOMPSON  80 PR D (TO BE PUB.) +CLELAND,COOPER,DRIS,ENGELS+       (PITT+BNL)

                                PAPERS NOT REFERRED TO IN DATA CARDS

BROWN     57 PR 108 1036        J BROWN, D GLASER, M PERL         (MICH+BNL)
NIETO     68 RMP 40 140         M NIETO                                 (STON)
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                    21   SIGMA0(1193,JP=1/2+) I=1

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                    21   (SIGMA-) - (SIGMA0) MASS DIFFERENCE (MEV)
D1   N    SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

D1        18     4.75      0.1             BURNSTEIN 64 HBC
D1        37     4.87      0.12            DOSCH     65 HBC
D1        12     5.01      0.12            SCHMIDT   65 HBC  SEE NOTE N          3/74
D1           . . . . . . . . .
D1   AVG         4.860     0.076   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
D1   STUDENT     4.860     0.077   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
D1   FIT         4.881     0.063  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*
                          (SEE IDEOGRAM BELOW )

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                    21   (SIGMA0) - (LAMBDA) MASS DIFFERENCE (MEV)

DL   N    SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

DL       208    76.63      0.28            SCHMIDT   65 HBC  SEE NOTE N          6/68
DL       109    76.23      0.55            COLAS     75 HLBC    LAMBDA-GAMMA DEC 12/75
DL           . . . . . . . . .
DL   AVG        76.55      0.25    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
DL   STUDENT    76.55      0.27    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
DL   FIT        76.86      0.08   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*

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Stable Particles

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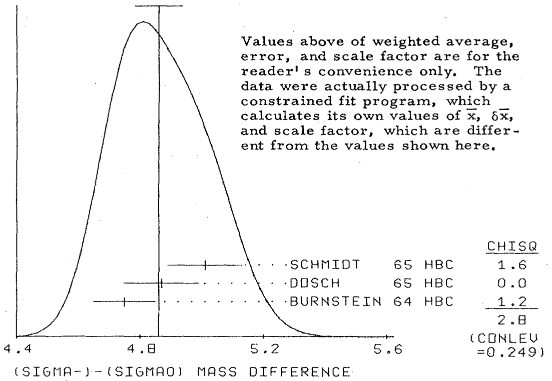
Data Card Listings

For notation, see key at front of Listings.

WEIGHTED AVERAGE = 4.860 ± 0.076
ERROR SCALED BY 1.2

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                    21  SIGMAO MEAN LIFE (UNITS 10**-19 SEC)

T           (E-14 OR LESS)          DAVIS     62 EMUL                        6/77
T           0.58      0.13          DYDAK     77 SPEC PRIMAKOFF EFFECT       6/77

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                    21  SIGMAO PARTIAL DECAY MODES

                                                               DECAY MASSES
P1      SIGMAO INTO LAMBDA GAMMA                              1115+   0
P2      SIGMAO INTO LAMBDA E+ E-                              1115+  .5+  .5
P3      SIGMAO INTO LAMBDA GAMMA GAMMA                        1115+   0+   0

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                    21  SIGMAO BRANCHING RATIOS

R1      SIGMAO INTO(LAMBDA E+ E-)/TOTAL                      (P2)/(P1+P2)
R1          (0.00545)   THEORET. CAL. FEINBERG  58             QUANTUM ELECT.    9/66

R2      SIGMAO INTO (LAMBDA GAMMA GAMMA)/(LAMBDA GAMMA)  (P3)/(P1)              12/75
R2              0.03  OR LESS  CL=.90    COLAS      75 HLBC                      12/75

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                             REFERENCES FOR SIGMAO

FEINBERG 58 PR 109 1019          G.FEINBERG                              (BNL)
DAVIS    62 PR 127 605           D DAVIS,R SETTI,M RAYMOND,G TOMASIN     (EFI)
BURNSTEI 64 PRL 13 66            BURNSTEIN,DAY,KEHOE,SECHI ZORN,SNOW     (UMD)
DOSCH    65 PL 14 239            DOSCH,ENGELMANN,FILTHUTH,HEPP,KLUGE+ (HEID)
SCHMIDT  65 PR 140 B 1328        P SCHMIDT                          (COLUMBIA)

COLAS    75 NP B91 253           +FARWELL,FERRER,SIX                     (ORSA)
DYDAK    77 NP B118 1            +NAVARRIA,OVERSETH,STEFFEN+(CERN+DORT+HEID)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

COURANT  63 PRL 10 409           COURANT,FILTHUTH,FRANZINI+    (CERN+UMD+NRL)

         QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

ALFF     65 PR 137 B1105         ALFF;GELFAND,NAUENBERG+ (COLUMBIA+RUTG+BNL)P

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                    22  XI-(1321,JP=1/2 ) I=1/2

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                    22  XI- MASS (MEV)

M   H   11(1317.0)    (2.2)          WANG       61 HLBC
M   H   18(1317.9)    (1.9)          FOWLER     61 HLBC
M   H   (OLD DATA AND LOW STATISTICS DROPPED ON SUGGESTION OF J R HUBBARD)
M      517 1321.4      0.4           JAUNEAU    63 FBC
M       62 1321.1      0.65          SCHNEIDER  63 HBC
M      241 1321.1      0.3           BADIER1    64 HBC
M       ALL MASSES ABOVE WERE RAISED 0.09 MEV BECAUSE LAMBDA MASS RAISED
M      149 1321.3      0.4           PJERROU    65 HBC                        11/67
M        6 1321.67     0.52          CHIEN      66 HBC   -  6.9 PBAR P        9/67
M      299 1321.4      1.1           LONDON     66 HBC                        6/66
M  G   195 1321.87     0.51          GOLDWASSE  70 HBC      5.5 K-P           8/70
M   G   USES LAMBDA MASS OF 1115.58-M(XI) IS 1322.18 IF M(LAMBDA)=1115.84     8/70
M      268 1321.12     0.41          WILQUET    72 HLBC                       1/73
M      632 1321.46     0.34          DIBIANCA   75 DBC      4.9 GEV/C K-D     1/77
M              . . . . . . . . . .
M   AVG      1321.34    0.14    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1321.34      0.16    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M   FIT      1321.32    0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*
        THE FIT ASSUMES XI AND ANTI-XI MASSES EQUAL.

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                    22  ANTI-XI+ MASS (MEV)

M1        1(1322.0)    (1.3)         BROWN      62 HBC      ANTI-XI-          7/66
M1        5 1320.69     0.93         CHIEN      66 HBC   +  6.9 PBAR P,ANTI   9/67
M1   S   12(1321.7)    (0.6)         SHEN       67 HBC      ANTI-XI-          10/67
M1       34 1321.2      0.4          STONE      70 HBC                        10/70
M1       35 1321.6      0.8          VOTRUBA    72 HBC      10 GEV/C K+ P     11/72
M1   S   THE ERROR IS STATISTICAL ONLY
M1             . . . . . . . . . .
M1  AVG      1321.20    0.33    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M1  STUDENT1321.20      0.36    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M1  FIT      1321.32    0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*
        THE FIT ASSUMES XI AND ANTI-XI MASSES EQUAL.

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                    22  (XI-) - (ANTI-XI+) MASS DIFFERENCE (MEV)

DM            1.0       1.1             CHIEN      66 HBC      6.9 PBAR P      9/67

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                    22  XI- MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM     2724    -0.1       2.1           BINGHAM    70 OSPK  - 1.8 GEV/C K-P    2/71
MM     2436    -2.1       0.8           COOL       74 OSPK -  1.8 GEV/C K-P   10/74
MM             . . . . . . . . . .
MM  AVG        -1.85      0.75    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
MM  STUDENT    -1.86      0.82    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    22  XI- MEAN LIFE (UNITS 10**-10)

T   H    11   (3.5)     (3.4)     (1.23) WANG       61 HLBC
T   H    18   (1.28)    (0.41)    (0.25) FOWLER     61 HLBC
T   H   (OLD DATA AND LOW STATISTICS DROPPED ON SUGGESTION OF J R HUBBARD)
T       517    1.86      0.15      0.14  JAUNEAU    63 FBC
T        62    1.55      0.31      0.31  SCHNEIDER  63 HBC
T       356   (1.77)    (0.12)           CARMONY    64 HBC    REP BY PJERROU 65
T       794    1.69      0.07            HUBBARD    64 HBC
T       246    1.70      0.12            PJERROU    65 HBC                     11/67
T   S     6   (1.37)    (0.51)           CHIEN      66 HBC   -  6.9 PBAR P      9/67
T       299    1.80      0.16            LONDON     66 HBC                      6/66
T   S         (1.67)    (0.07)           BURGUN     68 HBC    K-P AT 1.3-1.8    2/71
T      2610    1.61      0.04            DAUBER     69 HBC                      6/68
T       680    1.73      0.08      0.07  MAYEUR     72 HLBC   2.1 GEV/C K-      1/73
T      4303    1.63      0.03            BALTAY     74 HBC    1.75 GEV/C K-     3/74
T   S 2436    (1.637)   (0.050)          COOL       74 OSPK - 1.8 GEV/C K-P    10/74
T              1.67      0.08            DIBIANCA   75 DBC    4.9 GEV/C K-D     1/77
T      4286    1.609     0.028           HEMINGWAY  78 HBC    4.2 GEV/C K- P    7/79*
T       41K    1.665     0.065           BOURQUIN   79 SPEC   HYPERON BEAM     12/79*
T   S   THE ERROR IS STATISTICAL ONLY
T              . . . . . . . . . .
T   AVG        1.641     0.016     0.016  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T   STUDENT    1.640     0.019     0.018  AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    22  ANTI-XI+ MEAN LIFE (UNITS 10**-10)

T1  S     5   (1.51)    (0.55)           CHIEN      66 HBC  +  6.9 PBAR P,ANTI  9/67
T1  S    12   (1.9)     (0.7)     (0.5)  SHEN       67 HBC     ANTI-XI-        10/67
T1       34    1.6       0.3             STONE      70 HBC                     10/70
T1  S    35   (1.55)    (0.35)    (0.20) VOTRUBA    72 HBC     10 GEV/C K+ P   11/72
T1  S   THE ERROR IS STATISTICAL ONLY

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                    22  XI- PARTIAL DECAY MODES

                                                               DECAY MASSES
P1      XI- INTO LAMBDA PI-                                   1115+ 139
P2      XI- INTO LAMBDA E- NEUTRINO                           1115+  .5+   0
P3      XI- INTO NEUTRON PI-                                   939+ 139
P4      XI- INTO LAMBDA MU- NEUTRINO                          1115+ 105+   0
P5      XI- INTO SIGMAO E- NEUTRINO                           1192+  .5+   0
P6      XI- INTO SIGMAO MU- NEUTRINO                          1192+ 105+   0
P7      XI- INTO NEUTRON E- NEUTRINO                           939+  .5+   0
P8      XI- INTO NEUTRON MU- NEUTRINO                          939+ 105+   0
P9      XI- INTO SIGMA- GAMMA                                 1197+   0
P10     XI- INTO PROTON PI- PI-                                938+ 139+ 139
P11     XI- INTO PROTON PI- E- NEUTRINO                        938+ 139+  .5+   0
P12     XI- INTO PROTON PI- MU- NEUTRINO                       938+ 139+ 105+   0
P13     XI- INTO XIO E- NEUTRINO                              1314+  .5+   0

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                    22  XI- BRANCHING RATIOS

R1      XI- INTO (LAMBDA E- NEU)/(LAMBDA PI-) (UNITS 10**-3)
R1                                                        (P2)/(P1)
R1         1        155 EFFECTIVE DENOM.  CARMONY    63 HBC                      11/67
R1         0        260 EFFECTIVE DENOM.  JAUNEAU    63 HBC                      11/67
R1         0        220 EFFECTIVE DENOM.  BERGE      66 HBC                      11/67
R1         1        155 EFFECTIVE DENOM.  LONDON     66 HBC                      11/67
R1         0        717 EFFECTIVE DENOM.  TRIPPE     67 HBC                      11/67
R1         2       1976 EFFECTIVE DENOM.  HUBBARD    68 HBC                       6/68
R1  H      4   (1.15)    (0.90)    (0.55) HUBBARD    68 RVUE                      6/68
R1  H   HUBBARD 68 (RVUE) INCLUDES ALL ABOVE EVENTS                                6/68
R1         1    0.24      0.24            YEH        74 HBC                       7/75
R1        11    0.30      0.14            THOMPSON   80 ASPK    HYPERON BEAM      2/80*
R1              . . . . . . . . . .
R1  AVG         0.28      0.12     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT     0.28      0.13     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R2      XI- INTO (NEUTRON PI-)/(LAMBDA PI-) (UNITS 10**-3)
R2                                                        (P3)/(P1)
R2              5.0    OR LESS            FERRO-LUZ 63 HBC                        6/68
R2              1.1    OR LESS            DAUBER     69 HBC                       6/68
R2         0    3.0    OR LESS  CL=.90    YEH        74 HBC      760 EFF.DENOM.   7/75

R3      XI- INTO (LAMBDA MU- NEUTRINO)/TOTAL (UNITS 10**-3)
R3                                                        (P4)
R3             12.0    OR LESS            BERGE      66 HBC                       6/68
R3              1.3    OR LESS            DAUBER     69 HBC                       6/68
R3         1    0.35      0.35            YEH        74 HBC     2859 EFF.DENOM.   7/75
R3   H    11    0.31      0.13            HERBERT    78 ASPK    HYPERON BEAM      6/78*
R3   H  WE HAVE INCLUDED IN THE ERROR A 20 PCNT SYSTEMATIC ERROR IN               6/78*
R3   H  ADDITION TO THE STATISTICAL ERROR OF .11 QUOTED IN HERBERT 78.            6/78*
R3              . . . . . . . . . .
R3  AVG         0.31      0.12     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  STUDENT     0.31      0.13     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R4      XI- INTO (SIGMAO E- NEUTRINO)/TOTAL (UNITS 10**-3)
R4                                                        (P5)
R4              3.0    OR LESS            BERGE      66 HBC                       6/68
R4              0.5    OR LESS            DAUBER     69 HBC                       6/68
R4         0    0.53   OR LESS  CL=.90    YEH        74 HBC     4363 EFF.DENOM.   7/75

R5      XI- INTO (SIGO MU- NEU)/(LAM PI-) (UNITS 10**-3) (P6)/(P1)
R5              5.0    OR LESS            BERGE      66 HBC                       7/66
R5         0    0.76   OR LESS  CL=.90    YEH        74 HBC     3026 EFF.DENOM.   7/75

R6      XI- INTO (N E- NEU)/(LAMBDA PI-) (UNITS 10**-3)  (P7)/(P1)
R6             10.0    OR LESS  CL=.90    BINGHAM    65 RVUE                      9/66
R6         0    3.2    OR LESS  CL=.90    YEH        74 HBC      715 EFF.DENOM.   7/75
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

Ξ^-, Ξ^0

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R7       XI- INTO (SIGMA0 E- NEU + LAMBDA E- NEU)/TOTAL (10**-3)
R7                                                  (P2+P5)
R7        17     0.68       0.22          DUCLOS     71 OSPK    SEE NOTE D         10/71
R7   D   THIS EXPERIMENT CANNOT DISTINGUISH SIGMA0 FROM LAMBDA. THE CABIBBO
R7   D   THEORY PREDICTS SIGMA0 RATE ABOUT A FACTOR 6 SMALLER THAN THE
R7   D   LAMBDA.  TO GET A VALUE FOR THE TABLE R7 HAS BEEN AVERAGED WITH R1.

R8       XI- INTO (N MU- NEU)/(LAMBDA PI-) (UNITS 10**-3) (P8)/(P1)
R8        0    15.3    OR LESS  CL=.90   YEH          74 HBC          150 EFF.DENOM. 11/75

R9       XI- INTO (SIGMA- GAMMA)/(LAM PI-) (UNITS 10**-4) (P9)/(P1)
R9        0    11.5    OR LESS  CL=.90   YEH          74 HBC         2000 EFF.DENOM. 11/75

R10      XI- INTO (P PI- PI-)/(LAMBDA PI-) (UNITS 10**-4) (P10)/(P1)
R10       0     3.7    OR LESS  CL=.90   YEH          74 HBC         6200 EFF.DENOM. 11/75

R11      XI- INTO (P PI- E- NEU)/(LAM PI-) (UNITS 10**-4) (P11)/(P1)
R11       0     3.7    OR LESS  CL=.90   YEH          74 HBC         6200 EFF.DENOM. 11/75

R12      XI- INTO (P PI- MU- NEU)/(LAM PI-) (UNITS 10**-4) (P12)/(P1)
R12       0     3.7    OR LESS  CL=.90   YEH          74 HBC         6200 EFF.DENOM. 11/75

R13      XI- INTO (XI0 E- NEU)/(LAM PI-) (UNITS 10**-3)    (P13)/(P1)
R13       0     2.3    OR LESS  CL=.90   YEH          74 HBC         1000 EFF.DENOM. 11/75
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22 XI- DECAY PARAMETERS

RELATED TEXT SECTION VI D AND APPENDIX III

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A        ALPHA XI-
A    O         (-0.44)    (0.12)          JAUNEAU    63 FBC     SEE NOTE D BELOW  6/68
A    O    62   (-0.73)    (0.23)          SCHNEIDER  63 HBC     SEE NOTE D BELOW  6/68
A        240    -0.5       0.38           BADIER1    64 HBC     SEE NOTE D BELOW  6/68
A        356    -0.62      0.13           CARMONY    64 HBC     SEE NOTE D BELOW  6/68
A       1004    -0.365     0.068          BERGE      66 HBC     SEE NOTE D BELOW  6/68
A    L   364    -0.47      0.13           LONDON     66 HBC     SEE NOTE D BELOW  6/68
A              (-0.391)   (0.032)         BERGE 2    66 RVUE   INCLUDES ALL ABOVE 9/66
A    M 2529    (-0.375)   (0.051)         MERRILL    68 HBC                       6/68
A       2781    -0.391     0.045          DAUBER     69 HBC     SEE NOTE A BELOW
A       2724    -0.383     0.065          BINGHAM    70 OSPK                     10/70
A        820    -0.42      0.11           MAYEUR     72 HLBC    2.1 GEV/C K-      1/73
A       4303    -0.376     0.038          BALTAY     74 HBC     1.75 GEV/C K-     3/74
A       2436    -0.39      0.05           COOL       74 OSPK -  1.8 GEV/C K-P    10/74
A    B   414    -0.40      0.19           DIBIANCA   75 DBC     4.9 GEV/C K-D     1/77
A       6599    -0.370     0.032          HEMINGWAY  78 HBC     4.2 GEV/C K- P    7/79*
A               -0.49      0.04           CLELAND    80 ASPK    HYPERON BEAM      2/80*
A    O   OLD DATA NOT INCLUDED IN AVERAGE.
A    D   ERRORS MULTIPLIED BY 1.1 DUE TO APPROXIMATIONS USED FOR XI
A    D   POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)                    6/68
A    L   LONDON 66 USES ALPHA-LAMBDA = 0.62
A    M   DATA OF MERRILL 68 INCLUDED IN DAUBER 68.
A    A   USED ALPHA LAMBDA = 0.647 +- 0.020.
A    B   DIBIANCA 75 USES ALPHA LAMBDA = 0.647.                                   1/77
A            . . . . . . . . .
A    AVG        -0.403     0.017   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A    STUDENT    -0.398     0.019   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

F        PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA) (DEGREES)
F    O         (-16.0)    (45.0)          JAUNEAU    63 FBC     SEE NOTE D BELOW  6/68
F    O    62   (45.0)     (36.0)          SCHNEIDER  63 HBC     SEE NOTE D BELOW  6/68
F        356    54.0       30.0           CARMONY    64 HBC     SEE NOTE D BELOW  6/68
F       1004    0.         12.            BERGE      66 HBC     SEE NOTE D BELOW  6/68
F    L   364    0.0        20.4           LONDON     66 HBC     SEE NOTE D BELOW  6/68
F    M 2529    (9.8)      (11.6)          MERRILL    68 HBC                       6/68
F       2781   -14.        11.            DAUBER     69 HBC     SEE NOTE A BELOW
F       2724   -26.0       30.0           BINGHAM    70 OSPK                     10/70
F       4303    11.0        9.0           BALTAY     74 HBC     1.75 GEV/C K-     3/74
F       2436     5.0       16.0           COOL       74 OSPK -  1.8 GEV/C K-P    10/74
F    O   OLD DATA NOT INCLUDED IN AVERAGE.
F    D   ERRORS MULTIPLIED BY 1.2 DUE TO APPROXIMATIONS USED FOR XI
F    D   POLARIZATION. (SEE DAUBER 68 FOR DETAILED DISCUSSION)
F    L   LONDON 66 USES ALPHA-LAMBDA = 0.62
F    M   DATA OF MERRILL 68 INCLUDED IN DAUBER 68.
F    A   USED ALPHA LAMBDA = 0.647 +- 0.020.
F            . . . . . . . . .
F    AVG         2.0        5.7    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
F    STUDENT     2.0        6.2    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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REFERENCES FOR XI-


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FOWLER    61 PRL 6 134            FOWLER,BIRGE,EBERHARD,ELY,GOOD,POWELL+(LRL)
WANG      61 JETP 13 512          K WANG,T WANG,VIRYASOV,TING,SOLOVEV+ (JINR)
BROWN     62 PRL 8 255            BROWN,CULWICK,FOWLER,GAILLOUD +  (BNL+YALE)

CARMONY   63 PRL  10  381         CARMONY,PJERROU                      (UCLA)
FERRO-LU  63 PR 130 1568          FERRO-LUZZI,ALSTON,ROSENFELD,WOJCICKI (LRL)
JAUNEAU   63 SIENA CONF 4         JAUNEAU+           (EPOL+CERN+LOUC+RHEL+BERGEN)
   ALSO   63 PL   5  261          JAUNEAU,+          (EPOL,CERN,LOUC,RHEL,BERGEN)
SCHNEIDE  63 PL 4 360             H SCHNEIDER                          (CERN)

CARMONY   64 PRL 12 482           CARMONY,PJERROU,SCHLEIN,SLATER,STORK+(UCLA) J
BADIER1   64 DUBNA CONF I 593     BADIER,DEMOULIN,BARLOUTAUD+(EPOL,SACL,ZEEM)
HUBBARD   64 PR 135 B 183         HUBBARD,BERGE,KALBFLEISCH,SHAFER +    (LRL)
BINGHAM   65 PRSL  285  202       H H BINGHAM                          (CERN)
PJERROU   65 PRL 14 275           + SCHLEIN,SLATER,SMITH,STORK,TICHO   (UCLA)
PJERROU   65 THESIS               G M PJERROU                          (UCLA)

BERGE     66 PR  147  945         BERGE,EBERHARD,HUBBARD,MERRILL +      (LRL)
BERGE 2   66 BERKELEY CONF 46     BERGE,CABIBBO             (LRL,CERN(RVUE))
LONDON    66 PR 143 1034          LONDON,RAU,GOLDBERG,LICHTMAN+(BNL+SYRACUSE)
CHIEN     66 PR  152  1171        +LACH,SANDWEISS,TAFT,YEH,OREN +  (YALE+BNL)
SHEN      67 PL 25 B 443          B.C.SHEN,A.FIRESTONE,G.GOLDHABER  (UCB+LRL)
TRIPPE    67 PRIV. COMM.          T. TRIPPE                            (UCLA)

BURGUN    68 NP 88 447            +MEYER,PAULI,TALLINI, +    (SACL+CDEF+RHEL)
HUBBARD   68 PRL 20 465           HUBBARD,BERGE,DAUBER                  (LRL)
MERRILL   68 PR 167 1202          MERRILL,SHAFER                        (LRL)J

DAUBER    69 PR  179 1262         +BERGE,HUBBARD,MERRILL,MILLER         (LRL)J
BINGHAM   70 PR D1 3010           +COOK,HUMPHREY,SANDER,WILLIAMS+ (UCSD,WASH)
GOLDWASS  70 PR D1 1960           GOLDWASSER, SCHULTZ                   (ILL)
STONE     70 PL 32B 515           +BERLINGHIERI,BROMBERG,COHEN,FERBEL +(ROCH)

DUCLOS    71 NP B32 493           +FREYTAG,HEINTZE,HEINZELMAN,JONES+   (CERN)
MAYEUR    72 NP B47 333           +VAN BINST,WILQUET+   (BRUX+CERN+TUFT+LOUC)
VOTRUBA   72 NP B45 77            VOTRUBA,SAFDER,RATCLIFFE          (BIRM+EDIN)
WILQUET   72 PL 42B 372           +FLIAGINE,GUY,KNIGHT+ (BRUX+CERN+TUFT+LOUC)

BALTAY    74 PR D9 49             +BRIDGEWATER,COOPER,GERSHWIN+   (COLU+BING)J
COOL      74 PR D10 792           +GIACOMELLI,JENKINS,KYCIA,LEONTIC,LI+ (BNL)
   ALSO   72 PRL 29 1630          COOL,GIACOMELLI,JENKINS,KYCIA,LEONTIC+(BNL)
YEH       74 PR D10 3545          +GAIGALAS,SMITH,ZENDLE,BALTAY + (BING+COLU)
DIBIANCA  75 NP B98 137           F.A.DIBIANCA, R.J.ENDORF             (CARN)
HEMINGWA  78 NP B142 205          HEMINGWAY,ARMENTEROS+  (CERN+ZEEM+NIJM+OXF)
HERBERT   78 PRL 40 1230          +CLELAND,COOPER,DRIS,ENGELS +    (PITT+BNL)
BOURQUIN  79 PL 87B 297           (BRIS+GEVA+HEID+ORSA+RHEL+STRB+CERN+MELB)
CLELAND   80 PR D (TO BE PUB.) +COOPER,DRIS,ENGELS,HERBERT+       (PITT+BNL)
THOMPSON  80 PR D (TO BE PUB.) +CLELAND,COOPER,DRIS,ENGELS+       (PITT+BNL)
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23 XI0(1314,JP=1/2) I=1/2

23 XI0 MASS (MEV)

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M         1 1313.4       1.8              PALMER     68 HBC                       3/68
M        49 1315.2       0.92             WILQUET    72 HLBC                      1/73
M            . . . . . . . . .
M    AVG      1314.83    0.82    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    STUDENT1314.84      0.91    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M    FIT      1314.91    0.55   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*
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23 (XI-) - (XI0) MASS DIFFERENCE (MEV)

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D        23    6.8       1.6              JAUNEAU    63 FBC
D        45   (6.1)     (1.6)             CARMONY    64 HBC    REP BY PJERROU 65
D        88    6.1       0.9              PJERROU    65 HBC                      11/67
D        29    6.9       2.2              LONDON     66 HBC                       6/66
D            . . . . . . . . .
D    AVG       6.34      0.74    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D    STUDENT   6.34      0.80    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
D    FIT       6.41      0.55   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/80*
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23 XI0 MEAN LIFE (UNITS 10**-10)

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T        24    3.9       1.4       0.80 JAUNEAU    63 FBC
T        45   (3.5)     (1.0)     (0.8) CARMONY    64 HBC    REP BY PJERROU 65
T       101    2.5       0.4       0.3  HUBBARD    64 HBC
T        80    3.0       0.5            PJERROU    65 HBC                        11/67
T       340    3.07      0.22      0.20 DAUBER     69 HBC                         6/68
T    B  469   (2.85)    (0.20)    (0.18) BRIDGEWAT 72 HBC      1.75 GEV/C K-P     1/73
T    M  157    2.90      0.32      0.27 MAYEUR     72 HLBC     2.1 GEV/C K-       1/74
T    B  652    2.88      0.21      0.19 BALTAY     74 HBC      1.75 GEV/C K-      3/74
T    Z 6300    2.77      0.16           ZECH       77 SPEC NEUTRAL HYP. BEAM     12/77
T    M   MAYEUR 72 VALUE MODIFIED BY ERRATUM.                                     1/74
T    B   BALTAY 74 INCLUDES BRIDGEWATER 72.                                       3/74
T    Z   ZECH 77 VALUE IS FOR LAMBDA LIFETIME=2.69E-10. FOR LAM LIFETIME         12/77
T    Z   DIFFERENT FROM THIS, TAUXI0=(2.77-(TAULAMBDA-2.69))E-10.               12/77
T            . . . . . . . . .
T    AVG       2.903     0.099     0.093 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T    STUDENT   2.90      0.11      0.10  AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
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23 XI0 MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

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MM       42K   -1.20     0.06             BUNCE      79 SPEC                      1/80*
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23 XI0 PARTIAL DECAY MODES

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                                                        DECAY MASSES
P1       XI0 INTO LAMBDA PI0                            1115+ 134
P2       XI0 INTO PROTON PI-                             938+ 139
P3       XI0 INTO PROTON E- NEU                          938+  .5+   0
P4       XI0 INTO SIGMA+ E- NEU                         1189+  .5+   0
P5       XI0 INTO SIGMA- E+ NEU                         1197+  .5+   0
P6       XI0 INTO SIGMA+ MU- NEUTRINO                   1189+ 105+   0
P7       XI0 INTO SIGMA- MU+ NEUTRINO                   1197+ 105+   0
P8       XI0 INTO PROTON MU- NEUTRINO                    938+ 105+   0
P9       XI0 INTO LAMBDA GAMMA                          1115+   0
P10      XI0 INTO SIGMA0 GAMMA                          1192+   0
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23 XI0 BRANCHING RATIOS

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R1       XI0 INTO (PROTON PI-)/(LAMBDA PI0)  (UNITS 10**-5) (P2)/(P1)
R1          2700.     OR LESS                TICHO      63 HBC                    6/68
R1           500.     OR LESS                HUBBARD    66 HBC                    6/68
R1            90.     OR LESS                DAUBER     69 HBC                    6/68
R1        0  180.     OR LESS  CL=.90        YEH        74 HBC      1300 EFF.DENOM. 11/75
R1            3.6     OR LESS  CL=.90        GEWENIGER  75 SPEC                  11/75

R2       XI0 INTO (PROTON E- NEU)/(LAMBDA PI0) (UNITS 10**-3)
R2                                                       (P3)/(P1)
R2            27.0    OR LESS                TICHO      63 HBC                    6/68
R2             6.0    OR LESS                HUBBARD    66 HBC                    6/68
R2             1.3    OR LESS                DAUBER     69 HBC                    6/68
R2        0    3.4    OR LESS  CL=.90        YEH        74 HBC       670 EFF.DENOM. 11/75

R3       XI0 INTO (SIGMA+ E- NEU)/(LAMBDA PI0) (UNITS 10**-3)
R3                                                       (P4)/(P1)
R3            13.0    OR LESS                TICHO      63 HBC                    6/68
R3             7.0    OR LESS                HUBBARD    66 HBC                    6/68
R3             1.5    OR LESS                DAUBER     69 HBC                    6/68
R3        0    1.1    OR LESS  CL=.90        YEH        74 HBC      2100 EFF.DENOM. 11/75

R4       XI0 INTO (SIGMA- E+ NEU)/(LAMBDA PI0) (UNITS 10**-3)
R4                                                       (P5)/(P1)
R4             6.0    OR LESS                HUBBARD    66 HBC                    6/68
R4             1.5    OR LESS                DAUBER     69 HBC                    6/68
R4        0    0.9    OR LESS  CL=.90        YEH        74 HBC      2500 EFF.DENOM. 11/75

R5       XI0 INTO (SIGMA+ MU- NEU)/TOTAL (UNITS 10**-3)    (P6)
R5             7.0    OR LESS                HUBBARD    66 HBC                    6/68
R5             1.5    OR LESS                DAUBER     69 HBC                    6/68
R5        0    1.1    OR LESS  CL=.90        YEH        74 HBC      2100 EFF.DENOM. 11/75

R6       XI0 INTO (SIGMA- MU+ NEU)/TOTAL (UNITS 10**-3)    (P7)
R6             6.0    OR LESS                HUBBARD    66 HBC                    6/68
R6             1.5    OR LESS                DAUBER     69 HBC                    6/68
R6        0    0.9    OR LESS  CL=.90        YEH        74 HBC      2500 EFF.DENOM. 11/75

R7       XI0 INTO (PROTON MU- NEU)/TOTAL (UNITS 10**-3)    (P8)
R7             6.0    OR LESS                HUBBARD    66 HBC                    6/68
R7             1.3    OR LESS                DAUBER     69 HBC                    6/68
R7        0    3.5    OR LESS  CL=.90        YEH        74 HBC       664 EFF.DENOM. 11/75
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Stable Particles

Ξ^0, Ω^-

Data Card Listings

For notation, see key at front of Listings.

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R8      XIO INTO (LAMBDA GAMMA)/(LAM PIO) (UNITS 10**-3) (P9)/(P1)
R8        1    5.        5.              YEH       74 HBC      200 EFF.DENOM. 11/75

R9      XIO INTO (SIGMAO GAMMA)/(LAM PIO) (UNITS 10**-2) (P10)/(P1)
R9      0-1    6.5   OR LESS  CL=.90   YEH       74 HBC       60 EFF.DENOM. 11/75

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                     23   XIO DECAY PARAMETER

          RELATED TEXT SECTION VI D AND APPENDIX III

A       ALPHA XI 0
A              -0.09      0.46          PJERRCU    65 HBC     SEE NOTE D BELOW  6/68
A       146    -0.13      0.17          BERGE      66 HBC     SEE NOTE D BELOW  6/68
A   L    46    -0.2       0.4           LONDON     66 HBC     SEE NOTE D BELOW  6/68
A    M  490   (-0.33)    (0.11)         MERRILL    66 HBC     SEE NOTE D BELOW  6/68
A   A   739    -0.43      0.09          DAUBER     69         SEE NOTE A BELOW
A    B  440   (-0.52)    (0.09)         BRIDGEWAT  72 HBC     1.75 GEV/C K-P    1/73
A       130    -0.84      0.27          MAYEUR     72 HLBC    2.1 GEV/C K-      1/73
A   B   652    -0.54      0.10          BALTAY     74 HBC     1.75 GEV/C K-     3/74
A   U  6075    -0.490     0.042         BUNCE      78 SPEC                      7/79*
A    A   USED ALPHA LAMBDA = 0.647 +- 0.020.
A    D   ERRORS MULTIPLIED BY 1.1 DUE TO APPROXIMATIONS USED FOR XI
A    D   POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)
A   L    LONDON 66 USES ALPHA-LAMBDA = 0.62
A    M   MERRILL 66 REPLACED BY DAUBER 69
A    B   BRIDGEWATER 72 ERROR PURELY STATISTICAL.                               1/73
A   B    BALTAY 74 INCLUDES BRIDGEWATER 72.                                     3/74
A   U    BUNCE 78 USES ALPHA-LAMBDA = 0.647                                     7/79*
A             . . . . . . . . .
A    AVG      -0.474      0.045    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
A    STUDENT  -0.477      0.038    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                         (SEE IDEOGRAM BELOW )
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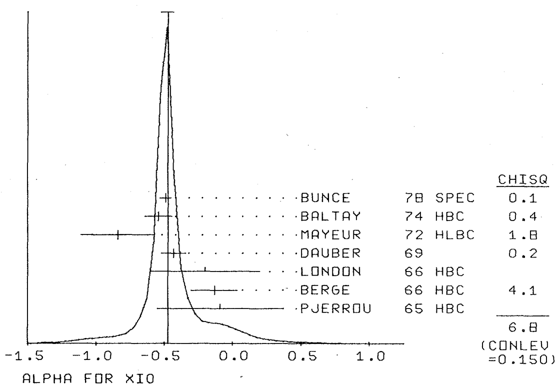
WEIGHTED AVERAGE = −0.474 ± 0.045
ERROR SCALED BY 1.3

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F       PHI ANGLE  (SIN(PHI)/COS(PHI)=BETA/GAMMA)  (DEGREES)
F       146    -8.       30.            BERGE      66 HBC     SEE NOTE D BELOW  6/68
F    M  490 (107.0)     (46.0)          MERRILL    66 HBC     SEE NOTE D BELOW  6/68
F   A   739    38.       19.            DAUBER     69 HBC     SEE NOTE A BELOW
F    B  440  (11.2)     (14.4)          BRIDGEWAT  72 HBC     1.75 GEV/C K-P    1/73
F   B   652    16.0      17.0           BALTAY     74 HBC     1.75 GEV/C K-     3/74
F    A   USED ALPHA LAMBDA = 0.647 +- 0.020.
F    D   ERRORS MULTIPLIED BY 1.2 DUE TO APPROXIMATIONS USED FOR XI
F    D   POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)
F    M   MERRILL 66 REPLACED BY DAUBER 69
F    B   BRIDGEWATER 72 ERROR PURELY STATISTICAL.                               1/73
F   B    BALTAY 74 INCLUDES BRIDGEWATER 72.                                     3/74
F             . . . . . . . . .
F    AVG       20.7      11.7      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
F    STUDENT   20.6      13.2      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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REFERENCES FOR XIO


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ALVAREZ   59 PRL 2 215           ALVAREZ,EBERHARD,GOOD,GRAZIANO,TICHO+ (LRL)
JAUNEAU   63 SIENA CONF 1 1      JAUNEAU+        (EPOL+CERN+LOUC+RHEL+BERGEN)
    ALSO  63 PL 4 49             JAUNEAU+        (EPOL+CERN+LOUC+RHEL+BERGEN)
TICHO     63 BNL CONF 410        HAROLD K TICHO                          (UCLA)

CARMONY   64 PRL 12 482          CARMONY,PJERROU,SCHLEIN,SLATER,STORK+(UCLA)
HUBBARD   64 PR 135 B 183        HUBBARD,BERGE,KALBFLEISCH,SHAFER +     (LRL)
PJERROU   65 PRL 14 275          + SCHLEIN,SLATER,SMITH,STORK,TICHO    (UCLA)
PJERROU   65 THESIS              G M PJERROU                           (UCLA)

BERGE     66 PR  147  945        BERGE,EBERHARD,HUBBARD,MERRILL +       (LRL)
HUBBARD   66 UCRL 11510          J RICHARD HUBBARD (THESIS,BERKELEY)    (LRL)
LONDON    66 PR 143 1034         LONDON,RAU,GOLDBERG,LICHTMAN+(BNL+SYRACUSE)
MERRILL   66  BERKELEY CONF      MERRILL,SHAFER,BERGE                   (LRL)
    ALSO  66 UCRL 16455          DEANE MERRILL (THESIS, BERKELEY)       (LRL)

PALMER    68 PL 26B  323         PALMER,RADOJICIC,RAU,RICHARDSON+ (BNL,SYRA)
DAUBER    69 PR  179 1262        +BERGE,HUBBARD,MERRILL,MILLER          (LRL)

BRIDGEWA  72 NEVIS 195(THESIS) ALBERT BRIDGEWATER                (COLUMBIA)
MAYEUR    72 NP B47 333          +VAN BINST,WILQUET+   (BRUX+CERN+TUFT+LOUC)
    ALSO  73 NP B53 268          ERRATUM TO MAYEUR 72
WILQUET   72 PL 42B 372          +FLIAGINE,GUY,KNIGHT+ (BRUX+CERN+TUFT+LOUC)

BALTAY    74 PR D9 49            +BRIDGEWATER,COOPER,GERSHWIN+   (COLU+BING)J
YEH       74 PR D10 3545         +GAIGALAS,SMITH,ZENDLE,BALTAY + (BING+COLU)
GEWENIGE  75 PL 57B 193          GEWENIGER,GJESDAL,PRESSER +      (CERN+HEID)
ZECH      77 NP B124 413         +DYDAK,NAVARRIA+       (SIEG+CERN+DORT+HEID)

BUNCE     78 PR D18 633          +HANDLER,MARCH,MARTIN+      (WISC+MICH+RUTG)
BUNCE     79 PL 86B 386          +OVERSETH,COX,DWORKIN+ (BNL+MICH+RUTG+WISC)
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$\boxed{\Omega^-}$

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                     24   OMEGA-(1672,JP=3/2+) I=0

                QUANTUM NUMBERS ASSIGNED FROM SU3
                SPIN 1/2 EXCLUDED BY DEUTSCHMANN 78

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                     24   OMEGA- MASS (MEV)

M   E    1(1615.)                    EISENBERG 54 EMUL                        9/73
M    F   1 1672.1      1.            FRY1      55 EMUL                        9/73
M    F   1 1670.6     (1.)           FRY2      55 EMUL                        9/73
M        1 1673.0      8.0           ABRAMS    64 HBC     INTO XI- PIO
M        3 1673.3      1.0           PALMER    68 HBC     K-P 4.6,5. GEV/C  11/69
M        3 1671.8      0.8           SCHULTZ   68 HBC     K-P 5.5 GEV/C     11/69
M        5 1674.2      1.6           SCOTTER   68 HBC     K-P 6.  GEV/C     11/69
M   B    6(1671.9)    (1.2)          SPETH     69 HBC     K-P 10. GEV/C     11/69
M    B  13 1671.43     0.78          ABCLV     73 HBC     K-P 10. GEV/C     12/73
M    D   4 1673.4      1.7           DIBIANCA  75 DBC     4.9 GEV/C K-D      1/77
M       41 1673.0      0.8           BAUBILLIE 78 HBC     8.25 GEV/C K-P     2/79*
M       27 1671.7      0.6           HEMINGWAY 78 HBC     4.2 GEV/C K-P      2/79*
M   E    EISENBERG 54 MASS CALCULATED FOR DECAY IN FLIGHT. ALVAREZ 73 HAS     9/73
M   E    SHOWN THAT THE OMEGA INTERACTED WITH AG NUCLEUS TO GIVE K- XI AG.    9/73
M    F   BOTH FRY EVENTS IDENTIFIED AS OMEGA- BY ALVAREZ 73.                  9/73
M    F   FRY MASSES ASSUME DECAY TO LAMBDA K- AT REST.  DECAY FROM ATOMIC     3/74
M    F   ORBIT COULD DOPPLER SHIFT THE K- ENERGY AND RESULTING OMEGA- MASS    3/74
M    F   BY SEVERAL MEV FOR FRY 2.  THIS SHIFT IS NEGLIGIBLE FOR FRY 1        3/74
M    F   BECAUSE THE OMEGA DECAY IS APPROXIMATELY PERPENDICULAR TO ITS        3/74
M    F   ORBITAL VELOCITY, AS IS KNOWN BECAUSE THE LAMBDA STRIKES THE         3/74
M    F   NUCLEUS (L.ALVAREZ, PRIVATE COMM. 1973).  WE HAVE CALCULATED THE     3/74
M    F   ERROR ASSUMING THAT ORBITAL N IS 4 OR LARGER.                        3/74
M    B   ABCLV VALUE INCLUDES THE SPETH 69 EVENTS.                           12/73
M    D   DIBIANCA 75 GIVES MASS FOR EACH EVENT.  WE QUOTE AVERAGE.            1/77
M            . . . . . . . . . .
M   AVG     1672.22    0.31    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1672.21     0.36    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                     24   ANTI-OMEGA+ MASS (MEV)

MB       1 1673.1      1.0           FIRESTONE 71 HBC     12 GEV/C K+D       3/71

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<u>Note on Ω^- Mean Life</u>

The value of the Ω^- mean life quoted in our 1978 edition was determined from the result of two large-statistics bubble chamber experiments, DEUTSCHMANN 78 and HEMINGWAY 78, with samples of 101 and 39 events, respectively. The result of HEMINGWAY 78 is about 2.5 standard deviations below that of DEUTSCHMANN 78 (see the Data Card Listings below). Another recent bubble chamber experiment with a sample of 40 events (BAUBILLIER 78) obtains a mean life consistent with the value of HEMINGWAY 78.

This year the first results from the CERN hyperon beam experiment are available. BOURQUIN 79 collected a total of some 2400 Ω^- events and were able to make a very accurate measurement of the mean life. Their value is in agreement with BAUBILLIER 78 and HEMINGWAY 78.

The origin of the discrepancy with DEUTSCHMANN 78 is not known. It could be connected with the fact that the data of DEUTSCHMANN 78 is bubble chamber data at relatively high energy where contamination from Ξ^- decays might present a problem. In our calculation of the average Ω^- mean life below, we do not include the value of DEUTSCHMANN 78.

Data Card Listings

For notation, see key at front of Listings.

Stable Particles

Ω^-, Λ_c^+

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                    24   OMEGA- MEAN LIFE (UNITS 10**-10 SEC)

T          1   (1.63)                      ABRAMS     64 HBC                       7/66
T          1   (0.7)                       BARNES 1   64 HBC                       7/66
T          1   (1.4)                       BARNES 2   64 HBC                       7/66
T          1   (1.85)                      COLLEY     65 HBC                       7/66
T          1   (1.5)                       RICHARDSO  65 HBC                       7/66
T          1   (1.20)                      SCHULTZ    68 HBC                      11/67
T          1   (0.06)                      SCHULTZ    68 HBC                      11/67
T          1   (0.63)                      SCHULTZ    68 HBC                      11/67
T          1   (0.25)                      SCOTTER    68 HBC                       6/68
T          1   (0.30)                      SCOTTER    68 HBC                       6/68
T          1   (0.71)                      SCOTTER    68 HBC                       6/68
T          1   (0.08)                      SCOTTER    68 HBC                       6/68
T          1   (1.04)                      SCOTTER    68 HBC                       6/68
T          1   (2.38)                      SCOTTER    68 HBC                       6/68
T    D    16   (1.39)    (0.45)    (0.31)  ABCLV      73 HBC    K-P 10. GEV/C     12/73
T          1   (0.135)                     DIBIANCA   75 DBC    4.9 GEV/C K-D      1/77
T          1   (0.482)                     DIBIANCA   75 DBC    4.9 GEV/C K-D      1/77
T          1   (0.702)                     DIBIANCA   75 DBC    4.9 GEV/C K-D      1/77
T          1   (0.228)                     DIBIANCA   75 DBC    4.9 GEV/C K-D      1/77
T         40    0.80      0.16      0.12   BAUBILLIE  78 HBC    8.25 GEV/C K-P     2/79*
T    D   101   (1.41)    (0.15)    (0.24)  DEUTSCHMA  78 HBC    10,16 GEV/C K- P   6/78*
T         39    0.75      0.14      0.11   HEMINGWAY  78 HBC    4.2 GEV/C K-P      2/79*
T       2437    0.822     0.028            BOURQUIN   79 SPEC   HYPERON BEAM      12/79*
T    D   DEUTSCHMANN 78 INCLUDES EVENTS OF ABCLV 73. EXCLUDED FROM AVERAGE         2/80*
T    D   BECAUSE OF SIGNIFICANT DISAGREEMENT WITH OTHER RECENT EXPERIMENTS.        2/80*
T             . . . . . . . . . .
T    AVG        0.819     0.028     0.026   AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T    STUDENT    0.819     0.030     0.028   AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    24   OMEGA- PARTIAL DECAY MODES

                                                               DECAY MASSES
P1      OMEGA- INTO LAMBDA K-                                1115+ 493
P2      OMEGA- INTO XIO PI-                                  1314+ 139
P3      OMEGA- INTO XI- PIO                                  1321+ 134
P4      OMEGA- INTO LAMBDA PI-                               1115+ 139
P5      OMEGA- INTO XI- GAMMA                                1321+   0
P6      OMEGA- INTO XI*(1530)0 PI-                           1533+ 139
P7      OMEGA- INTO XIO E- NEU                               1314+  .5+   0

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                    24   OMEGA- BRANCHING RATIOS

R1      OMEGA- INTO LAMBDA K-                                (P1)
R1   F    1    EVENT                      FRY1       55 EMUL                      11/73
R1   F    1    EVENT                      FRY2       55 EMUL                      11/73
R1   F   BOTH FRY EVENTS IDENTIFIED BY ALVAREZ 73.                                11/73
R1        2    EVENTS                     PALMER     68 HBC                       11/69
R1        3    EVENTS                     SCHULTZ    68 HBC                       11/69
R1        5    EVENTS 1 XI PI DECAY AMB.SCOTTER      68 HBC                       11/69
R1       13    EVENTS +2 AMBIG. WITH XI-ABCLV        73 HBC    K-P 10. GEV/C     12/73
R1        2    EVENTS                     DIBIANCA   75 DBC    4.9 GEV/C K-D      1/77
R1     1920    0.686     0.013            BOURQUI2   79 SPEC   HYPERON BEAM       1/80*

R2      OMEGA- INTO XIO PI-                                  (P2)
R2        5    EVENTS                     PALMER     68 HBC                       11/69
R2        3    EVENTS                     SCOTTER    68 HBC                       11/69
R2        3    EVENTS +1 AMBIG.WITH SIG-ABCLV        73 HBC    K-P 10. GEV/C     12/73
R2        2    EVENTS                     DIBIANCA   75 DBC    4.9 GEV/C K-D      1/77
R2      317    0.234     0.013            BOURQUI2   79 SPEC   HYPERON BEAM       1/80*

R3      CMEGA- INTO XI- PIO                                  (P3)
R3        1    EVENT                      ABRAMS     64 HBC                       11/69
R3        1    EVENT                      PALMER     68 HBC                       11/69
R3        1    EVENT                      SCOTTER    68 HBC                       11/69
R3        1    EVENT                      ABCLV      73 HBC    K-P 10. GEV/C     12/73
R3      145    0.080     0.008            BOURQUI2   79 SPEC   HYPERON BEAM       1/80*

R4      OMEGA- INTO (LAMBDA PI-)/TOTAL    (UNITS 10**-3)  (P4)
R4        0   (1.3)  OR LESS  CL=.90      BOURQUI2   79 SPEC                      1/80*

R5      CMEGA- INTO (XI- GAMMA)/TOTAL     (UNITS 10**-3)  (P5)
R5        0   (3.1)  OR LESS  CL=.90      BOURQUI2   79 SPEC                      1/80*

R6      CMEGA- INTO (XI*(1530)0 PI-)/TOTAL (UNITS 10**-3)(P6)
R6        1    2.     APPROX              BOURQUI2   79 SPEC                      1/80*

R7      CMEGA- INTO (XIO E- NEU)/TOTAL    (UNITS 10**-2)  (P7)
R7        3    1.     APPROX              BOURQUI2   79 SPEC                      1/80*

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                    24   OMEGA- DECAY PARAMETERS

          RELATED SECTION VI D IN TEXT

AL      ALPHA FOR OMEGA- TO K- LAMBDA
AL       15   -0.66      0.36     0.30  KOCHER     74                             10/74
AL       40    0.58      0.50           BAUBILLIE 78 HBC      8.25 GEV/C K-P       2/79*
AL       40   -0.2       0.4            HEMINGWAY 78 HBC      4.2 GEV/C K-P        2/79*
AL             . . . . . . . . . . .
AL   AVG      -0.26      0.33    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
AL   STUDENT  -0.27      0.28    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                         (SEE IDEOGRAM BELOW )

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                                 REFERENCES FOR OMEGA-

EISENBER 54 PR 96 541           Y EISENBERG                          (CORNELL)
FRY1     55 PR 97 1189          FRY,SCHNEPS,SWAMI                       (WISC)
FRY2     55 NC 2 346            FRY,SCHNEPS,SWAMI                       (WISC)

ABRAMS   64 PRL 13 670          + BURNSTEIN,GLASSER +               (UMD+NRL)
BARNES 1 64 PRL  12  204        V E BARNES,CCNNOLLY,CRENNELL,CULWICK+ (BNL)
BARNES 2 64 PL 12 134           V E BARNES,CONNOLLY,CRENNELL,CULWICK+ (BNL)
COLLEY   65 PL 19 152           COLLEY,DODD +(BIRM+GLAS+LOIC+MPIM+OXF+RHEL)
RICHARDS 65 BAPS 10 115         RICHARDSON,BARNES,CRENNEL+   (BNL+SYRACUSE)
SAMIOS   65 ARGONNE CONF 189    N P SAMIOS                        ((RVUE) BNL)

PALMER   68 PL 26B 323          PALMER,RADOJICIC,RAU,RICHARDSON+ (BNL,SYRA)
SCHULTZ  68 PR  168  1509       SCHULTZ+     (ILL,ARGONNE,NORTHWESTERN,WISC)
SCOTTER  68 PL 26B 474          SCOTTER+      (BIRM,GLASGOW,LOIC,MUNICH,OXF)
SPETH    69 PL  29B 252         SPETH+        (AACHEN,BERLIN,CERN,LOIC,VIEN)

FIRESTON 71 PRL 26 410          +GOLDHABER,LISSAUER,SHELDON,TRILLING  (LRL)
ABCLV    73 NP B61 102          AACHEN+BERLIN+CERN+LONDON+VIENNA COLLABOR.
ALVAREZ  73 PR D8 702           LUIS W. ALVAREZ                          (LBL)
KCCHER   74 PL 51B 193          KOCHER,WERNHARD                    (INNS+VIEN)
DIBIANCA 75 NP B98 137          F.A.DIBIANCA, R.J.ENDORF                (CARN)
BAUBILLI 78 PL 78B 342          BAUBILLIER +         (BIRM+CERN+GLAS+MSU+LPNP)
DEUTSCHM 78 PL 73B 96           DEUTSCHMANN+(AACH+BERL+CERN+INNS+LOIC+VIEN)
HEMINGWA 78 NP B142 205         HEMINGWAY,ARMENTEROS+   (GERN+ZEEM+NIJM+CXF)
BOURQUIN 79 PL 87B 297            (BRIS+GEVA+HEID+ORSA+RHEL+STRB+CERN+MELB)
BOURQUI2 79 PL 88B 192            (BRIS+GEVA+HEID+ORSA+RHEL+STRB+CERN+MELB)
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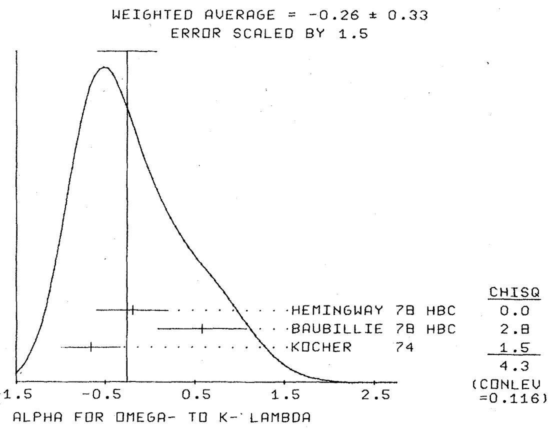


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Λ_c^+

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                 33   LAMBDA/C+(2260,JP=   )

                 FOR (SIGMA/C) - (LAMBDA/C) MASS DIFFERENCE SEE
                 THE SIGMA/C SECTION OF THE BARYON DATA CARD LISTINGS

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                 33   LAMBDA/C+ MASS (MEV)

M     C   1 2260.     20.                CAZZOLI    75 HBC  +  LAMBDA 2PI+ PI-     3/77
M    S    1(2360.)   (590.)              SUGIMOTO   75 EMUL    INTO SIGMA PIO      3/77
M    S    1(2230.)   (560.)              SUGIMOTO   75 EMUL    INTO SIGMA ETAO     3/77
M     K  60 2260.     (10.)              KNAPP      76 SPEC -  ANTILAM 2PI- PI+    3/77
M    B    1(2248.)   OR MORE             BARISH     77 DBC     MODE P4 BELOW       3/77
M         1 2295.     15.                ANGELINI   79 HYBR    INTO P K- PI+      12/79*
M         6 2257.     10.                BALTAY     79 HLBC +  INTO LAMBDA PI+     7/79*
M         1 2254.     12.                CNOPS      79 DBC     MODE P11BELOW      12/79*
M     G  30 2262.     10.                GIBONI     79 SPEC    K- P PI+            2/80*
M        39 2285.      6.                ABRAMS     80 SMK2 +- K- P PI+ + C.C.     1/80*
M     C  CAZZOLI 75 IS BNL EXPT.  SEES (NEUTRINO P --> MU- LAMBDA 3PI+ PI-)        3/77
M     C  EVENT WITH M(LAMBDA 4PI)=2426+-12MEV.  LARGE DS=-DQ RATE (SAME AS         3/77
M     C  DS=DQ) SUGGESTS CHARM.  DERUJULA 75 PREDICTS 2 STATES NEAR THIS           3/77
M     C  MASS WHICH DECAY STRONGLY BY PI+ EMISSION (MASS DIFF 160 AND 220MEV      3/77
M     C  FOR THE TWO STATES) TO THE LOWEST MASS CHARMED BARYON.  THE THREE         3/77
M     C  POSSIBLE PI+ EMISSION MASS DIFFS FOR THIS EVT ARE 338+-12, 327+-12        3/77
M     C  AND 166+-15MEV.  WE USE THE LATTER FOR THE ABOVE QUOTED MASS.             3/77
M    S   SUGIMOTO 75 VALUES ASSUME DECAY TRACK IDENTIFICATION AS SIGMA+-.          3/77
M    S   VALUES TAKEN FROM GAISSER 76 TABLE 3. VERY SPECULATIVE INTERP.           3/77
M     K  KNAPP 76 IS FNAL WIDE BAND PHOTON BEAM ON BE TARG. THEY SEE PEAK IN      3/77
M     K  ANTILAM 2PI- PI+ BUT NOT IN ANTILAM 2PI+ PI-.  THEY ALSO SEE AN          3/77
M     K  ANTILAM  2PI+ 2PI- STATE AT 2.5GEV CASCADING VIA PI- EMISSION TO         3/77
M     K  THE 2.26 GEV STATE.                                                      3/77
M    B   BARISH 77 IS ANL EXPT.  SEES ONE DILEPTON EVENT WHICH IS CONSISTENT      3/77
M    B   WITH NEU P --> MU- SIGMA/C++, SIGMA/C++ --> LAMBDA/C+ PI+  AND           3/77
M    B   LAMBDA/C+ --> P PI- PIO KOBAR E+ NEU.  THIS INTERPRETATION GIVES         3/77
M    B   ABOVE MASS LIMIT. IT IS A VERY SPECULATIVE INTERPRETATION.               3/77
M     G  GIBONY 79 RESULT CHANGED FROM 2255.+-4. BY AUTHORS.  SEE KERNAN 79.      2/80*
M           . . . . . . . . . .
M    AVG     2272.9      6.5      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
M    STUDENT2271.8       5.9      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )
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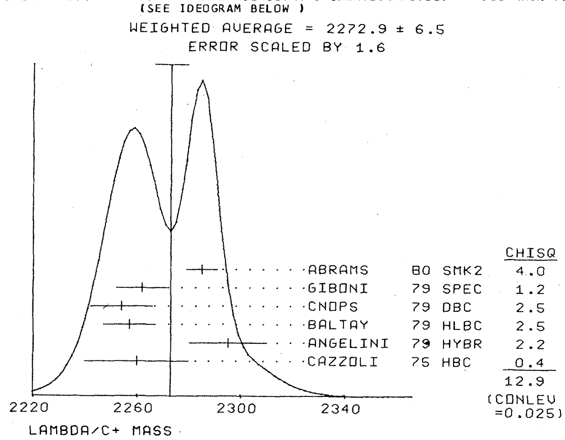


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Stable Particles

Λ_c^+, HEAVY LEPTON SEARCHES

Data Card Listings

For notation, see key at front of Listings.

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                        33  LAMBDA/C+ MEAN LIFE (UNITS 10**-12 SEC)

T   S   1   (4.5)                      SUGIMOTO  75 EMUL    INTO SIGMA PIO     3/77
T   S   1   (0.68)                     SUGIMOTO  75 EMUL    INTO SIGMA ETAO    3/77
T       1    0.73                      ANGELINI  79 HYBR    INTO P K- PI+     12/79*
T   S   SUGIMOTO 75 VALUES ASSUME DECAY TRACK IDENTIFICATION AS SIGMA+-.       3/77
T   S   VALUES TAKEN FROM GAISSER 76 TABLE 3.  VERY SPECULATIVE.               3/77

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                        33  LAMBDA/C+ WIDTH FROM MASS SPECTRUM

W    C  60   75.    OR LESS            KNAPP     76 SPEC -  ANTILAM 2PI- PI+  3/77
W    C  KNAPP 76 MEASURES WIDTH 40+-20MEV CONSISTENT WITH THEIR EXPT           3/77
W    C  RESOLUTION (30MEV) FOR A ZERO WIDTH STATE.                              3/77

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                        33  LAMBDA/C+ PARTIAL DECAY MODES

                                                       DECAY MASSES
P1      LAMBDA/C+ INTO LAMBDA PI+ PI+ PI-             1115+ 139+ 139+ 139
P2      LAMBDA/C+ INTO SIGMA+ PIO                     1189+ 134
P3      LAMBDA/C+ INTO SIGMA+ ETA                     1189+ 548
P4      LAMBDA/C+ INTO P PI- PIO KO E+ NEU             938+ 139+ 134+ 497+
P5      LAMBDA/C+ INTO LAMBDA PI+                     1115+ 139
P6      LAMBDA/C+ INTO P KOBAR                         938+ 497
P7      LAMBDA/C+ INTO P KOBAR PI- PI+                 938+ 497+ 139+ 139
P8      LAMBDA/C+ INTO K- PI+ P                        493+ 139+ 938
P9      LAMBDA/C+ INTO K*(892)0 P                      892+ 938
P10     LAMBDA/C+ INTO K- N*3/2(1232)++                493+1232
P11     LAMBDA/C+ INTO P K*(892)- PI+                  938+ 892+ 139

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N       NCTE CN VERY TENTATIVE MODES P2, P3, AND P4                           3/77
N        THESE MODES ARE VERY TENTATIVE.  P2 AND P3 ARE FROM SUGIMOTO 75      3/77
N        (SEE GAISSER 76 REVIEW) AND P4 IS FROM BARISH 77.  EACH IS FRCM A    3/77
N        SINGLE EVENT.                                                        3/77

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                        33  LAMBDA/C+ BRANCHING RATIOS

R1      LAMBDA/C+ INTO (LAMBDA PI+ PI+ PI-)/TOTAL            (P1)
R1        1 SEEN                       CAZZOLI   75 HBC  NEU BROADBAND       2/80*
R1       60 SEEN                       KNAPP     76 SPEC NEU WIDEBAND        2/80*
R1        2 SEEN                       BALTAY    79 HLBC NEU WIDEBAND        2/80*
R1       12 SEEN                       GIBONI    79 SPEC P P AT 63 GEV ECM  12/79*
R1       18 SEEN                       LOCKMAN   79 SPEC P P AT 53,62 GEVECM 12/79*

R2      LAMBDA/C+ INTO (K- PI+ P)/TOTAL                      (P8)
R2       90 SEEN                       DRIJARD   79 SFM  P P AT 62.8 GEV ECM 12/79*
R2       98 SEEN                       GIBONI    79 SPEC P P AT 63 GEV ECM  12/79*
R2       18 SEEN                       LOCKMAN   79 SPEC P P AT 53,62 GEVECM 12/79*
R2       39    0.022    0.010          ABRAMS    80 SMK2    E+E- 5.2 GEV ECM  1/80*

R3      LAMBDA/C+ INTO (K*(892)0 P)                          (P9)
R3        1 SEEN                       ANGELINI  79 HYBR NEU 300 GEV WIDE   12/79*
R3       47 SEEN                       DRIJARD   79 SFM  P P AT 52.5 GEV ECM 12/79*

R4      LAMBDA/C+ INTO K- N*3/2(1232)++                      (P10)
R4       40 SEEN                       DRIJARD   79 SFM  P P AT 52.5 GEV ECM 12/79*

R5      LAMBDA/C+ INTO (LAMBDA PI+)                          (P5)
R5        6 SEEN                       BALTAY    79 HLBC NEU WIDEBAND        2/80*

R6      LAMBDA/C+ INTO (P KOBAR)                             (P6)
R6        5 SEEN                       BALTAY    79 HLBC NEU WIDEBAND        2/80*

R7      LAMBDA/C+ INTO (P K*892)- PI+)                       (P11)
R7        1 SEEN                       CNOPS     79 DBC  NEU BROADBAND       2/80*

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                        REFERENCES FOR LAMBDA/C+

CAZZOLI   75 PRL 34 1125          +CNOPS,CONNOLY,LOUTTIT,MURTAGH+         (BNL)
SUGIMOTO  75 PTP 53 1540          +SATO,SAITO                        (TWAS+TCKY)
KNAPP     76 PRL 37 882           +LEE,LEUNG,SMITH +     (COLU+HAWA+ILL+FNAL)
BARISH    77 PR D15 1             +DERRICK,DOMBECK,MUSGRAVE +        (ANL+PURD)

ANGELINI  79 PL 84B 150            (ANKA+LIBH+CERN+DUUC+LOUC+KEYN+PISA+ROMA+)
BALTAY    79 PRL 42 1721          +CAROUMBALIS,FRENCH,HIBBS,HYLTON+(COLU+BNL)
CNOPS     79 PRL 42 197           +CONNOLLY,KAHN,KIRK,MURTAGH,PALMER+   (BNL)
DRIJARD   79 PL 85B 452           +FISCHER+    (CERN+CDEF+DORT+HEID+LAPP+WARS)
GIBONI    79 PL 85B 437           +DIBITONTO+   (AACH+CERN+HARV+MUNC+NWES+UCR)
KERNAN    79  LEPTON CONF.FNAL    A. KERNAN                               (UCR)
LOCKMAN   79 PL 85B 443           +MEYER,RANDER,SCHLEIN,WEBB+       (UCLA+SACL)

ABRAMS    80 PRL 44 10            +ALAM,BLOCKER,BOYARSKI+            (SLAC+LBL)

                        THEORY AND REVIEW

DERUJULA  75 PR D12 147           +GEORGI,GLASHOW                        (HARV)
GAISSER   76 PR D14 3153          T.K.GAISSER,F.HALZEN              (BART+WISC)
LEE       77 PR D15 157           +QUIGG,ROSNER                          (FNAL)
MULLER    79 CERN/EP 79-148       F.MULLER (CARGESE LEC.1979)            (CERN)

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HEAVY LEPTON SEARCHES

Data on the $\tau^{\pm}(1800)$ heavy lepton are listed in a separate section above, following the e and μ listings.

The following section contains information on searches for heavy leptons of other types and searches for the $\tau^{\pm}$ in collisions other than e^+e^-.

Several types of heavy leptons (that is, non-strongly-interacting fermions other than e and μ) have been proposed. In the Data Card Listings we distinguish four types.[1,2] Each has a corresponding antiparticle with opposite charge and lepton number. For convenience we omit writing the antiparticles in the following descriptions. The four types are:

Sequential Leptons (L^-, ν_L). Such a pair is assumed to have its own separately strictly conserved lepton number $n_L = +1$. This means that the radiative decays

$$\left.\begin{array}{l} L^- \to e^- \gamma \\ L^- \to \mu^- \gamma \end{array}\right\} \text{ are forbidden },$$

while the weak decays (assuming m_{L^-} sufficiently massive)

$$\left.\begin{array}{l} L^- \to \nu_L\, e^- \bar{\nu}_e \\ L^- \to \nu_L\, \mu^- \bar{\nu}_\mu \\ L^- \to \nu_L \text{ hadrons} \end{array}\right\} \text{ are allowed }.$$

There could be an increasing mass sequence of such pairs. It is frequently assumed that the neutrinos are massless.

Decay rates are assumed calculable from conventional weak interactions theory. For L^- mass between 1 and 3 GeV, the branching fraction to each of the two leptonic modes should be roughly 10% to 20%. For L^- mass above 1 GeV, the mean life should be $\lesssim 10^{-12}$ sec, too short to be observed in a track chamber.[1]

Paraleptons (E^+, E^0) and (M^+, M^0). These pairs have the same lepton numbers as the opposite-charge ordinary leptons, i.e., e^- and μ^-, respectively. Radiative decays are again forbidden and decays similar to those allowed for L^- are allowed here, e.g.,

$$M^+ \to \nu_\mu\, e^+ \nu_e$$

$$\text{or} \qquad M^+ \to \nu_\mu\, \mu^+ \nu_\mu \ .$$

However, the lightest member is not stable as is the case for sequential leptons, so that bizarre decay schemes such as (assuming $m_{E^0} < m_{E^+}$)

$$E^+ \to E^0\, \mu^+ \nu_\mu, \quad E^0 \to e^- e^+ \nu_e$$

Data Card Listings

For notation, see key at front of Listings.

Stable Particles

HEAVY LEPTON SEARCHES

are allowed.

Heavy leptons of this type (and/or a neutral intermediate boson Z^0) are desired in unified gauge theories of weak and electromagnetic interactions to cancel unphysical high energy behavior in such processes as $e^+e^- \to W^+W^-$.[3]

Ortholeptons (F^- and N^-). These have the same lepton numbers as e^- and μ^-, respectively. They may or may not have associated neutral leptons. Radiative decays are allowed in addition to weak modes similar to those of sequential leptons. The radiative mode can dominate or can be relatively unimportant depending on the model.[4] Decays such as

$$F^- \to e^- + \text{hadrons}$$

are also allowed.

Long-Lived Penetrating Particles. Heavy leptons could have long mean lives under certain circumstances. For example, if $m_{\nu_L} > m_{L^-}$, then L^-, the sequential lepton, is completely stable since its lepton number is conserved.

Experimental Results. The results are summarized in the Data Card Listings below. Mass limits for all types are listed together in subsection M. Mass information on the $\tau^\pm(1800)$ is no longer included here but has been moved into the new $\tau^\pm(1800)$ section.

The Listings also contain cross-section upper limits reported as results of unsuccessful searches. We no longer list cross sections for anomalous $e\mu$ events in e^+e^- collisions. These cross sections are consistent with coming from $e^+e^- \to \tau^+\tau^-$ where the $\tau^\pm(1800)$ is assumed to be a spin-1/2 Dirac point particle with a mass about 1800 MeV.

References

1. M. L. Perl and P. Rapidis, SLAC-PUB-1496 (October 1974).
2. C. H. Llewellyn Smith, Invited paper presented at the Royal Society Meeting on New Particles and New Quantum Numbers, 11 March 1976, Oxford Ref. 33/76.
3. J. D. Bjorken and C. H. Llewellyn Smith, Phys. Rev. D7, 887 (1973).
4. F. Wilczek and A. Zee, Nucl. Phys. B106, 461 (1976).


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          PROPERTIES OF THE TAU+-(1800) HEAVY LEPTON AND ITS ASSOCIATED
          NEUTRINO ARE LISTED SEPARATELY ABOVE FOLLOWING THE E AND MU
          LISTINGS.  THE FOLLOWING SECTION CONTAINS INFORMATION ON SEARCHES
          FOR HEAVY LEPTONS OF OTHER TYPES AND SEARCHES FOR TAU+- IN
          COLLISIONS OTHER THAN E+E-.  WE LIST MASS LIMITS AND CROSS SECTION
          UPPER LIMITS REPORTED AS NEGATIVE SEARCH RESULTS.  WE NO LONGER
          LIST CROSS SECTIONS FOR THE ESTABLISHED PROCESS E+ E- --> TAU+ TAU-
          AS WAS DONE IN OUR 1977 SUPPLEMENT.

M         HEAVY LEPTCN MASS LIMITS (GEV)
M    H   0     1.0   OR MORE                BEHREND   65 SPEC -  ORTHOELECTRON(F)  6/77
M    T  NONE BETWEEN .12   AND  .57         BETOURNE  65 SPEC -  ORTHOELECTRON(F)  6/77
M    U  NCNE BETWEEN .3    AND  .7          BUDNITZ   66 SPEC -  ORTHOELECTRON(F)  6/77
M    R  NONE BETWEEN .2    AND  .92         BARNA     68 CNTR -  LCNG-LIVED        6/77
M    R  NONE BETWEEN .97   AND 1.03         BARNA     68 CNTR -  LONG-LIVED        6/77
M    Y  NONE BETWEEN .1    AND 1.3          BOLEY     68 SPEC -  ORTHOELECTRON(F)  6/77
M    L  NCNE BETWEEN .2    AND  .6          LIBERMAN  69 OSPK -  ORTHOMUON(N)      6/77
M    W         .490 OR MORE                 ROTHE     69 RVUE                      6/77
M    I  NONE BETWEEN .26   AND 1.32         LICHTENST 70 SPEC -  ORTHOELECTRON(F)  6/77
M    M  20     (.424)     (.013)     (.002)RAMM       70 HLBC 0  ORTHOMUON(N)      6/77
M    M  22     (.431)     (.004)            RAMM      71 HLBC -  ORTHOMUON(N)      6/77
M    S   0     0.1   OR MORE                ANSORGE   73 HBC  -  LONG-LIVED        6/77
M    B   0     0.6   OR MORE                BACCI     73 ELEC +- ORTHOELECTRON(F)  1/76
M    B   0     2.2   OR MORE                BACCI     73 ELEC +- ORTHOELECTRON(F)  1/76
M    C   0     2.0   OR MORE  CL=.90        BARISH    73 ASPK +  PARAMUON (M)      2/74
M    D   0     1.4   OR MORE  CL=.95        BERNARDIN 73 ASPK +- ANY NON-RAD TYPE  2/74
M    D   0     1.0   OR MORE  CL=.95        BERNARDIN 73 ASPK +- ANY NON-RAD TYPE  2/74
M    N  NONE BETWEEN 0.55 AND 4.5           BUSHNIN   73 CNTR -  LONG-LIVED        2/74
M    E   0     2.4   OR MORE  CL=.90        EICHTEN   73 HLBC +  PARAMUON (M)      3/74
M    J         7.8   OR MORE  CL=.95        HANSON    73 WIRE    ORTHOELECTRON(F)  6/77
M    A         1.8   OR MORE  CL=.90        ASRATYAN  74 HLBC +- ORTHOMUON (N)    11/75
M    F         8.4   OR MORE  CL=.90        BARISH    74 SPEC +  PARAMUON (M)      7/74
M    G   NONE BETWEEN 0 AND 2.0             GITTLESON 74 SPEC    ORTHOMUON (N)    12/77
M    O   0     1.15  OR MORE  CL=.95        ORITO     74 ASPK +- ANY NON-RAD TYPE 11/75
M    K   NONE BETWEEN 0.25 AND 2.3          BACCI     77 SPEC +- ORTHOELECTRON(F) 12/77
M    C         2.4-4.6                      COX       77 NEUTRAL-->MU-MU+NU       12/79*
M    C         6.9-8.1                      COX       77 CHARGED-->NEUTRAL MU-ANU 12/79*
M    P         1.2   OR MORE                MEYER     77 SMAG 0  NEUTRAL          12/77
M    Y        10.3   OR MORE  CL=.98        ASRATYAN  78      -  ORTHOMUON (N)     1/79*
M    Q   0     7.5   OR MORE                CNOPS     78 HLBC -  ORTHOMUON (N)     8/78*
M    Q   0     9.0   OR MORE                CNOPS     78 HLBC +  PARAMUON (M)      8/78*
M    Z        10.0   OR MORE                ERRIQUEZ  78 BEBC                      1/79*
M    V        12.    OR MORE  C=.90         HOLDER    78      +  PARAMUON (M)      6/78*
M
M                                           COMMENTS                               3/77
M      LIMITS APPLY CNLY TO HEAVY LEPTON TYPE GIVEN IN COMMENT AT RIGHT ON         3/77
M      CATA CARD.  SEE REVIEW ABOVE FOR DESCRIPTION OF TYPES.                      3/77
M      IN CCMMENTS BELOW; ALL BEAMS ARE MU TYPE NEUTRINO OR ANTINEUTRINO.          3/77
M      L,E,M,F,N STAND FOR SEQUENTIAL LEPTCN,PARA-ELECTRON,PARA-MUON,              3/77
M      CRTHO-ELECTRCN,ORTHO-MUON RESPECTIVLY.                                      3/77
M
M    H BEHREND 65 IS DESY EXPT. LOCKS FOR E P-->F P, F--> E GAMMA.                 6/77
M    H THIS MASS LIMIT CORRESPONDS TO A LIMIT ON LAMBDA**2 OF 6.25*10**-4.         6/77
M    T BETOURNE 65 IS ORSAY EXPT. LOOKS FOR E P -->F P. MASS OF .12                6/77
M    T CORRESPONDS TO COUPLING CONSTANT LAMBDA**2 GT .0016, MASS OF .57            6/77
M    T TO LAMBDA**2 GT .22.                                                        6/77
M    U BUDNITZ 66 IS CEA EXPT. LOOKS FOR E P-->F P.                                6/77
M    R BARNA 68 IS SLAC PHOTOPRODUCTION EXPT.                                      6/77
M    Y BOLEY 68 IS CEA EXPT. LOOKS FOR E P-->F P. MASS OF .1 CORRESPONDS           6/77
M    Y TO COUPLING CONSTANT LAMBDA**2 GT 3*10**-4, MASS LIMIT OF 1.3 TO            6/77
M    Y LAMBDA**2 GT .01.                                                           6/77
M    L LIBERMAN 69 IS A BNL EXPT MEASURING MUON BREMSSTRAHLUNG.                    6/77
M    W ROTHE 69 EXAMINES PREVIOUS DATA ON MU PAIR PROD AND PI AND K DECAYS         6/77
M    I LICHTENSTEIN 70 IS CORNELL EXPT MEASURING E BREMSSTRAHLUNG.                 6/77
M    I MASS LIMIT DEPENDS ON COUPLING CONSTANT. FIRST VALUE ABOVE IS FOR           6/77
M    I LAMBDA**2 GT .17, SECOND IS FOR LAMBDA**2 GT .42.                           6/77
M    M RAMM 70 FINDS PEAK IN MU PI COMBINED MASS PRODUCED BY NEUTRINO              6/77
M    M INTERACTICNS. HE ALSO CLAIMS EVIDENCE FOR THIS IN KOMU3 DECAYS IN           6/77
M    M HBC WHERE PI MU COMBINED MASS PEAKS IN SAME REGION. CLARK 72 FINDS          6/77
M    M NO EVIDENCE FOR PI MU PEAK IN HIGH STATISTICS KOL3 EXPT.                    6/77
M    M RAMM 71 SEES PEAK IN MU GAMMA COMBINED MASS PRODUCED BY NEUTRINOS.          6/77
M    S ANSORGE 73 LOOKS FOR ELECTRON PAIR PROD AND ELECTRON-LIKE BREMSS.           6/77
M    B BACCI 73 IS FRASCATI E+E- EXPT. LOOKS FOR F --> E GAMMA.                    1/76
M    B MASS LIMIT DEPENDS ON COUPLING CONSTANT LAMBDA FOR THIS DECAY.              1/76
M    B FIRST VALUE ABOVE IS FOR LAMBDA**2 GT 9*10**-5, 2ND IS FOR                  1/76
M    B LAMBDA**2 GT 10**-3.                                                        1/76
M    C BARISH 73 IS FNAL 50,145 GEV NEU EXPT.  LOOKS FOR (NEU NUCLEON -->          3/77
M    C M+ ANYTHING). ASSUMES (M+ --> MU+ NEU NEU) WITH BR=.3.                      3/77
M    D BERNARDINI 73 IS FRASCATI E+E- EXPT. FIRST VALUE ASSUMES UNIVERSAL          2/74
M    D COUPLING TO ORDINARY LEPTONS.  SECOND VALUE ALSO ASSUMES COUPLING           2/74
M    D TO HADRONS.                                                                 2/74
M    N BUSHNIN 73 IS SERPUKOV 70 GEV P EXPT. MASSES ASSUME MEAN LIFE ABOVE         2/74
M    N 7E-10 AND 3E-8 RESPECTIVELY. CALCULATED FROM CROSS SEC(DC BELOW)            2/74
M    N AND 30 GEV MUON PAIR PRODUCTION DATA.                                       2/74
M    E EICHTEN 73 IS CERN 1-10GEV NEU EXPT. LOOKS FOR M+ PRODUCED IN               2/76
M    E NEU NUCL --> M+ HADRCNS ASSUMING 15 PERCENT DECAY TO E+ NEU NEU.            2/76
M    J HANSON 73 LOOK FOR DEVIATIONS FROM QED IN E+ E- -->2 GAMMA. THEY            6/77
M    J MEASURE THE PRODUCT OF THE F MASS * THE COUPLING CONSTANT LAMBDA,           6/77
M    J WHICH IS THE VALUE QUOTED ABOVE.                                            6/77
M    A ASRATYAN 74 USES EICHTEN 73 DATA ON NEU NUCL --> E- HADRONS AND             2/76
M    A ANTINEU NUCL --> E+ HADRONS TO SET LIMITS ON ORTHOMUON PRODUCTION.          2/76
M    F BARISH 74 IS FNAL 50,135 GEV NEU EXPT.  LOOKS FOR (NEU NUCLEON -->          7/74
M    F M+ ANYTHING).  ASSUMES (M+ -->MU+ NEU NEU) WITH BR=.3.                      7/74
M    G GITTLESON 74 IS MU P --> P ORTHOMUON SEARCH. COUPLING CONSTANT             12/77
M    G LAMBDA**2 IS <.01 FOR MASS UP TO .7 GEV, LIMIT ON LAMBDA**2 RISES          12/77
M    G TO <.1 FOR MASS OF 2.0 GEV.                                                12/77
M    O ORITO 74 LOOKED FOR H+H- PAIRS GIVING MU-E PAIRS. MASS LIMIT REFERS         3/74
M    O TO ANY NON-RADIATIVE TYPE HEAVY LEPTON; L, E, M, F, N.                      3/74
M    O COUPLING TO HADRON ASSUMED FROM THEORETICAL MODELS.                         3/74
M    K BACCI 77 IS SAME TYPE AS BACCI 73. LOWER MASS LIMIT CORRESPONDS TO         12/77
M    K LAMBDA**2 LIMIT OF 4*10**-5, UPPER VALUE IS FOR LAMBDA**2 LIMIT OF         12/77
M    K 1.5*10**-3.                                                                12/77
M    C COX 77 ASSUMES TRIMUON EVENTS OF BENVENUTI2 77 ARE A NEGATIVE HEAVY        12/79*
M    C LEPTCN DECAYING TO A NEUTRAL HEAVY LEPTON MU- NUBAR.                       12/79*
M    P MEYER 77 LOOKS FOR NARROW NEUTRAL RESONANCE IN(E PI)AND(MU PI)             12/77
M    P CHANNELS PRODUCED BY E+E- AT 6.8 GEV (ECM). ASSUMED TO BE DECAY            12/77
M    P PRODUCT OF THE TAU. SEE SECTION NE BELOW.
M    Y ASRATYAN 78 ANALYZES DEPENDENCE OF N.C./C.C. CN ENERGY OF ASSOC.            1/79*
M    Y HADRONS. USES DATA OF HOLDER 77 (PL 72B, 254)--NUMU INTERACTIONS            1/79*
M    Y AT CERN-SPS.                                                                1/79*
M    Q CNOPS 78 IS FNAL EXPT LOOKING FOR NEUMU NE --> L+(-), FOLLOWD BY            8/78*
M    Q L+(-) --> E+(-) NEU NEU.                                                    8/78*
M    Z ERRIQUEZ 78 IS CERN SPS EXPT. LOOKS FOR NUMU NUCLEON-->MU- E+ X.            1/79*
M    Z FINDS CS FOR PRODUCING HVY LEPT--> E+ <.7*10**-3 *C.C. CS.                  1/79*
M    V HOLDER 78 IS A CERN NEU EXPT LOOKING FOR NEUMU NUCLEON --> MU+ ANY          6/78*
M    V THING. ASSUMES M+ --> MU+ 2NEUMU WITH BR=0.2 .                              6/78*

COS     CCSMOLOGICAL LIMITS ON MASS OF NEUTRAL HEAVY LEPTONS                      12/79*
COS      NONE 70 EV TO 23 MEV             SATO      77      MASSIVE NEUTRINOS     12/79*
COS      NCNE 30 EV TO 2.5 GEV            VYSOTSKII 77                            12/79*
COS      NONE 50 EV TO 100 KEV            DICUS     78      RADIATIVE DECAY       12/79*
COS      NONE  3 EV TO 10 GEV             SCHRAMM   78                            12/79*
COS            60 GEV OR LESS             HUT       79         HEAVY NEUTRINOS    12/79*
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Stable Particles

INTERMEDIATE BOSON, QUARK SEARCHES

Data Card Listings

For notation, see key at front of Listings.

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NEU      HEAVY LEPTON EVIDENCE (NEUTRINO NUCLEON)
NEU      SEE ALSO SECTION 'Y' IN 'CHARMED HADRON SEARCHES' AND
NEU      SECTION 'T' IN 'OTHER NEW PARTICLE SEARCHES'.
NEU   B   6 TRIMUON EVENTS              BENVENU1  77 NEUL    5/6NEU,1/6NEUBAR  1/78
NEU   E  10 MU+ MU-, 3 MU- MU- EVENTS   BENVENU2  77 NEUL                      1/78
NEU   S                                 BOSETTI   78 HYBR                      6/78*
NEU   B  BENVENUT1 77 IS FNAL EXPT. TRIMUON EVENTS CAN BE EXPLAINED BY PROD   7/77
NEU   B  OF A NEW HEAVY LEPTON -->MU- NEUBAR NEW LIGHTER LEPTON --> MU+ MU-   7/77
NEU   B  NEUTRINO. SEE ALSO BENVENUT2 77, ALBRIGHT 77 AND BARGER 77 FOR       7/77
NEU   B  FURTHER ANALYSIS. HEAVIER LEPTON HAS M=7 (+3,-1) GEV, LIGHTER HAS    7/77
NEU   B  M=3.5(+1.5,-.4) GEV.                                                 7/77
NEU   E  BENVENUT2 77 IS FNAL EXPT WHICH ANALYSES THE DIMUON EVENTS THAT ARE  7/77
NEU   E  UNLIKELY TO COME FROM CHARM PRODUCTION BECAUSE OF MUON MOMENTA.      7/77
NEU   E  THEY MAY BE EXPLAINED BY SAME CASCADE DECAY PROCESS AS TRIMUON       7/77
NEU   E  EVENTS.                                                              7/77
NEU   S  BOSETTI 78 ANALYSES MOMENTA OF MUONS FROM DIMUON EVENTS USING        6/78*
NEU   S  200 GEV NARROW BAND NEU BEAM AT CERN. FINDS (NEUMU P --> HVY-LEPT)/  6/78*
NEU   S  (NEUMU P --> MU) < 0.06 (90 PCNT CL) WHERE HVY-LEPT --> E- NU(E)     6/78*
NEU   S  NU(HVY-LEPT) 15 PCNT OF THE TIME.                                    6/78*

DC      HEAVY LEPTON PRODUCTION DIFF. CROSS SEC. (P NUCLEON) (CM**2/SR-GEV)
DC    G   0  1.6E-37 OR LESS   CL=.90   GOLOVKIN  72 CNTR- 70GEV P, SERPUKHOV 1/76
DC    B   0  4. E-38 OR LESS   CL=.90   BUSHNIN   73 CNTR- 70GEV P, SERPUKHOV 2/74
DC    G  MASS RANGE 1 TO 4.5 GEV,THETA=0,P=25 GEV/C.                         1/76
DC    B  BUSHNIN 73 HEAVY LEPTON PATH TRAVERSES 6800 GM/CM**2 ABSORBER.       2/74
DC    B  DIFFERENTIAL CROSS-SECTION MEASURED AT P=30 GEV/C THETA= 2 MRAD.     3/74

IC      INVARIANT HEAVY LEPTON PROD. CROSS SEC. (P NUCLEON) (CM**2/GEV**2)
IC    S   0  5.4E-39 OR LESS   CL=.90   CRONIN    74 SPEC -  M=1-6.8 GEV      1/76
IC    B   0  6.4E-35 OR LESS   CL=.90   BINTINGER 75 SPEC +- M=1-5 GEV        2/76
IC    A   0  1.8E-33 OR LESS   CL=.90   ARMITAGE  79 SPEC    M=1.87 GEV       7/79*
IC    S  CRONIN 74 IS AN FNAL 300 GEV P CU EXPT.  LOOKED FOR LONG LIVED       2/76
IC    S  PENETRATING PARTICLES.  ABOVE LIMIT ASSUMES STABLE.  MULTIPLY IT BY  2/76
IC    S  EXP(1.22E-8*M/TAU) FOR MASS M(GEV) AND LIFETIME TAU(SEC). LIMIT      2/76
IC    S  OBTAINED AT THETA(LAB) = 77 MRAD, PT = 2.38 GEV/C.                   4/77
IC    B  BINTINGER 75 IS A 30-300 GEV P C EXPT.  LOOKED FOR LONG LIVED        2/76
IC    B  PENETRATING PARTICLES.  ABOVE LIMIT ASSUMES STABLE.  MULTIPLY IT BY  2/76
IC    B  EXP(3.5E-8*M/TAU/P) FOR MASS M(GEV), LIFETIME TAU(SEC), MOM.P(GEV).  2/76
IC    B  OBTAINED AT THETA(LAB) = 91 MRAD, PT = 1-2.25 GEV/C.                 4/77
IC    A  ARMITAGE 79 IS CERN-ISR EXPT AT ECM=53 GEV.  VALUE IS FOR X=0 AND    7/79*
IC    A  PT=.15.                                                              7/79*

CN      NEUTRAL HEAVY LEPTON PRODUCTION CROSS SECTION  (CM**2)
CN    K   5 (1. E-37 OR MORE)           KRISHNASW 75 CNTR +0-  M=2-5 GEV      2/76
CN    B   0                             BENVENUTI 75 SPEC  0                  2/76
CN    K  KRISHNASWAMY 75 IS KOLAR GOLD MINE COSMIC RAY EXPT.  TYPICAL EVENT   2/76
CN    K  HAS VERTEX IN AIR 70 CM FROM WALL WITH THREE OBSERVED CHARGED        2/76
CN    K  TRACKS.  AUTHORS SUGGEST NEU+ROCK GIVES NEW PARTICLE WITH MEAN LIFE  2/76
CN    K  10E-9 SEC OR LONGER.  DE RUJULA 75 GIVES ANOTHER INTERPRETATION.     2/76
CN    K  SEE ALSO RAJASEKARAN 75.                                             8/76
CN    B  BENVENUTI 75 IS AN FNAL EXPERIMENT WHICH ROUGHLY SIMULATES THE       2/76
CN    B  KRISHNASWAMY 75 EXPT. BUT APPARENTLY CONTRADICTS IT, FINDING NO      2/76
CN    B  EVENTS. SENSITIVE TO DECAYS OF NEUTRAL PENETRATING PARTICLES         3/77
CN    B  PRODUCED BY THE PRIMARY PROTONS OR BY SECONDARY NEUTRINO             3/77
CN    B  INTERACTIONS IN THE 1 KM. NEUTRINO BEAM EARTH SHIELD.                3/77

N       EVIDENCE FOR NEUTRAL HEAVY LEPTON PRODUCED IN NEUTRINO INTERATIONS   12/77
N     B   1 SEEN                        BARANOV   77 HLBC  0 SERPUKHOV       12/77
N     A   2 SEEN                        BARANOV   79 HLBC  0 SERPUKHOV        7/79*
N     B  BARANOV EVENT INTERPRETED AS NEU N --> P 2PI0 NEUTRAL H.LEPTON WITH 12/77
N     B  H.LEPTON --> MU- E+ NEU. MASS=1.4-2.1 GEV, TAU LESS THAN OR         12/77
N     B  APPROXIMATELY EQUAL 6*10**-12 SEC. EVENT ALSO HAS A POSSIBLE        12/77
N     B  CHARMED PARTICLE INTERPRETATION.                                    12/77
N     A  BARANOV 79 INCLUDES BARANOV 77 EVENT. OTHER EVENT MAY BE HEAVY       7/79*
N     A  LEPTON WITH MASS BETW 1.4 AND 2.4 GEV, LIFETIME <5*10**-12 SEC,      7/79*
N     A  DECAYING TO MU- E+ NEU(E).                                           7/79*

MM      UNEXPLAINED MISSING NEUTRAL (HEAVY LEPTON?) MOMENTUM /TOTAL MOMENTUM
MM    E        0.05      0.03           ELLIOT    77 CALO                     1/78
MM    E  ELLIOT 77 IS SLAC 10.5 GEV PI+ P --> P NPI+- NEUTRALS.  FINDS THAT   1/78
MM    E  NEUTRAL SPECTRUM CAN BE EXPLAINED BY GAMMA, KO, LAMBDA, NEUTRON.     1/78

CP      NEUTRAL HEAVY LEPTON PROD. CROSS SEC. (PROTON NUCLEON) (CM**2)
CP    F   0  1. E-29 OR LESS            FAISSNER  76 HLBC 0                   1/77
CP    B   0  2.8E-35 OR LESS   CL=.90   BECHIS    78 SPEC  0                  8/78*
CP    F  FAISSNER 76 LIMIT ASSUMES STABLE NEUTRAL WEAKLY INTERACTING LEPTON.  1/77
CP    F  ALSO RULES OUT DE RUJULA 75 INTERP. OF 5 KRISHNASWAMY 75 EVENTS AS   1/77
CP    F  (P NUCLEON --> L+ X, L+ --> LO X) UNLESS L+ MASS IS ABOVE 3 GEV.     1/77
CP    B  BECHIS 78 IS 400 GEV FNAL EXPT. LOOKS FOR P NUCLEON --> L+,          8/78*
CP    B  L+ --> LO X, LO --> MU PI OR E PI. RESULT IS CL=.90 FOR MASS OF LO   8/78*
CP    B  < 1 GEV, LIFETIME BETW 10**-10 AND 10**-8 SEC.(VALID ONLY FOR CASES  8/78*
CP    B  WHEN LO UNACCOMPANIED BY MUON OF P>10 GEV.)                          8/78*

NE      NEUTRAL HEAVY LEPTON PROD. CROSS SECTION (E+ E-)  (CM**2)            12/77
NE    M       4.5E-36 OR LESS  CL=.90   MEYER     77 SMAG E+E- 6.8 GEV (ECM) 12/77
NE    M  MEYER 77 EXPT LOOKS FOR NARROW NEUTRAL RESONANCE IN E-PI AND MU-PI  12/77
NE    M  CHANNELS. VALUE GIVEN IS FOR MASS OF .5 GEV, AND IS PRODUCT OF CS*  12/77
NE    M  BR(TAU--> NEW NEUTRAL LEPTON)*BR(NEUTRAL LEPTON--> E OR MU PI). IF  12/77
NE    M  MASS OF NEUTRAL LEPTON IS 1.5 GEV, LIMIT BECOMES 2.5E-36. SEE S25M. 12/77

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REFERENCES FOR HEAVY LEPTON SEARCHES


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BEHREND  65 PRL 15 900         +BRASSE,ENGLER,GANSSAUGE+          (DESY+KARL)
BETOURNE 65 PL 17 70           +NGUYEN NGOC,PEREZ Y JORBA+              (ORSA)
BUDNITZ  66 PR 141 1313        +DUNNING,GOITEIN,RAMSEY,WALKER,WILSON(HARV)
BARNA    68 PR 173 1391        +COX,MARTIN,PERL,TAN,TONER,ZIPF+(SLAC+STAN)
BOLEY    68 PR 167 1275        +ELIAS,FRIEDMAN,HARTMANN,KENDALL+ (MIT+CEA)

BERNARDI 69 NCL 1 15           BERNARDINI,FELICETTI+        (FRAS+NAPL+ROMA)
LIBERMAN 69 PRL 22 663         +HOFFMAN,ENGELS,IMRIE+(HARV+CASE+MCGI+SLAC)
ROTHE    69 NP B10 241         K.W.ROTHE,A.M.WOLSKY                    (PENN)
LICHTENS 70 PR D1 825          LICHTENSTEIN,ASH,BERKELMAN,HARTILL+     (CORN)
RAMM     70 NATURE 227 1323    C.A.RAMM                                (CERN)
   ALSO  72 NATURE 237 388     CLARK,ELIOFF,FIELD,FRISCH,JOHNSON+       (LBL)

RAMM     71 NAT.PH.SC.230 145  C.A.RAMM                                (CERN)
GOLOVKIN 72 PL 42B 136         +GRACHEV,KHODYREV,KUBAROVSKY+           (SERP)
ANSORGE  73 PR D7 26           +BAKER,KRZESINSKI,NEALE,RUSHBROOKE+     (CAVE)
BACCI    73 PL 44B 530         +PARISI,PENSO,SALVINI,STELLA+      (ROMA+FRAS)
BARISH   73 PRL 31 410         +BARTLETT,BUCHHOLZ,HUMPHREY+        (CIT+FNAL)

BERNARDI 73 NC 17A 383         BERNARDINI,BOLLINI,BRUNINI+(CERN+BGNA+FRAS)
   ALSO  70 LNC 4 1156         ALLES-BORELLI,BERNARDINI,BOLLINI+       (CERN)
BUSHNIN  73 NP B58 476         +DUNAYTZEV,GOLOVKIN,KUBAROVSKY +        (SERP)
   ALSO  72 PL 42B 136         GOLOVKIN,GRACHEV,SHODYREV +             (SERP)
EICHTEN  73 PL 46B 281         +DEDEN+(AACH+BELG+CERN+EPOL+MILA+LALO+LCUC)
HANSON   73 NCL 7 587          +LEONG,NEWMAN,LAW,LITKE+(MIT+HARV+CEA+HAIF)

ASRATYAN 74 PL 49B 488         +GERSHTEIN,KAFTANOV,KUBANTZEV,LAPIN+ (SERP)
BARISH   74 PRL 32 1387        +BARTLETT,BUCHHOLZ,MERRITT +        (CIT+FNAL)
CRONIN   74 PR D10 3093        +FRISCH,SHOCHET,BOYMOND,MERMOD + (EFI+PRIN)
GITTLESO 74 PR D10 1379        GITTLESON,KIRK+         (HARV+ROCH+COLU+FNAL)
ORITO    74 PL 48B 165         +VISENTIN,CERADINI,CONVERSI +      (FRAS+ROMA)

BENVENUT 75 PRL 35 1486        BENVENUTI,CLINE,FORD+ (HARV+PENN+WISC+FNAL)
BINTINGE 75 PRL 34 982         BINTINGER,CURRY+          (EFI+HARV+PENN+WISC)
BACCI    77 PL 71B 227         +DEZORZI,PENSO,STELLA+             (ROMA+FRAS)
KRISHNAS 75 PL 57B 105         KRISHNASWAMY,MENON+             (BOMBAY+OSAKA)
   ALSO  75 PRL 35 628         DE RUJULA,GEORGI,GLASHOW                (HARV)
   ALSO  75 PRAMANA 5 78       RAJASEKARAN,SARMA                       (TATA)

FAISSNER 76 PL 60B 401         +HASERT+(AACH+BELG+CERN+EPOL+MILA+OXF+LCUC)
BARANOV  77 PL 70B 269         +VOLKOV,GERSHTEIN,IVANILOV +            (SERP)
   ALSO  77 SJNP 26 57         BARANOV,VOLKOV,GERSHTEIN,IVANILOV    +(SERP)
BENVENU1 77 PRL 38 1110        BENVENUTI,CLINE+ (FNAL+HARV+PENN+RUTG+WISC)
   ALSO  77 PRL 38 1187        ALBRIGHT,SMITH,VERMASEREN          (FNAL+STON)
   ALSO  77 PRL 38 1190        BARGER,GOTTSCHALK+       (WISC+ZARAGOZA+RHEL)
BENVENU2 77 PRL 38 1183        BENVENUTI,CLINE+ (FNAL+HARV+PENN+RUTG+WISC)

CAVALLIS 77 LNC 20 337         CAVALLI-SFORZA,GOGGI +        (PAVI+PRIN+UMD)
COX      77 PR D16 2897        PAUL COX,ASIM YILDIZ                (UNH+HARV)
ELLIOT   77 PR D15 1851        +FORTNEY,GOSHAW,LAMSA,LOOS+        (DUKE+ALBA)
MEYER    77 PL 70B 469         +NGUYEN,ABRAMS,ALAM+     (SLAC+LBL+NWES+HAWA)
SATO     77 PTP 58 1775        +KOBAYASHI                             (KYOTO)
VYSOTSKI 77 JETPL 26 188       VYSOTSKII,DOLGOV,ZELDOVICH              (ITEP)

ASRATYAN 78 PL 76B 237         ASRATYAN,KUBANTSEV                      (ITEP)
BECHIS   78 PRL 40 602         +CHANG,DOMBECK,ELLSWORTH,GLASSER,LAU+ (UMD)
BOSETTI  78 PL 73B 380         +DEDEN +      (AACH+BONN+CERN+LOIC+OXF+SACL)
CNOPS    78 PRL 40 144         +CONNOLLY,KAHN,KIRK,MURTAGH +       (BNL+COLU)
DICUS    78 PR D17 1529        +KOLB,TEPLITZ,WAGONER          (TEXA+VPI+STAN)
ERRIQUEZ 78 PL 77B 227                   BARI+BIRM+BRUX+EPOL+RHEL+SACL+LOUC
HOLDER   78 PL 74B 277         +KNOBLOCH,MAY +  (CERN+DORT+HEID+SACL+BGNA)
SCHRAMM  78 EFI PREPRINT 78-25DAVID N. SCHRAMM                          (EFI)

ARMITAGE 79 NP B150 87         +BENZ,BOBBINK+ (CERN+DARE+FOM+MCHS+UTRECHT)
BARANOV  79 PL 81B 261         +IVANILOV,KONYUSHKO,KORABLEV+           (SERP)
HUT      79 PL 87B 144         +OLIVE                         (AMSTERDAM+EFI)
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INTERMEDIATE BOSON SEARCHES

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M       W BOSON MASS LIMITS (GEV)
M     B   0     1.7    OR MORE  CL=.99   BERNARDIN 65 HYBR +  NEU N, CERN       2/74
M     B   0     2.0    OR MORE  CL=.90   BURNS     65 OSPK +  NEU N, BNL        2/74
M     C   0     3.8    OR MORE  CL=.90   BARISH    73 ASPK +  W+ TO LEP+NEU=.2  2/74
M     C   0     4.5    OR MORE  CL=.90   BARISH    73 ASPK +  W+ TO LEP+NEU=.5  2/74
M     C   0     4.7    OR MORE  CL=.90   BARISH    73 ASPK +  W+ TO LEP+NEU=.8  2/74
M     E   0     5.0    OR MORE  CL=.95   BERGESON  73 ELEC                      1/76
M     U   0 NONE WITH MASS 10-20 GEV     BUSSER    74 WIRE +-0 P-P,52.7 GEV CM  8/76
M     A   0 NONE WITH MASS 5.5-8.5 GEV ABRAMOV     77 CNTR +-                  12/77
M     A  ABRAMOV 77 IS 70 GEV P-CU EXPT AT SERP LOOKING AT DIRECT MUONS OF     12/77
M     A  HIGH TRANSVERSE MOM. RESULT IS MODEL DEPENDENT.                       12/77
M     B  LOOKED FOR (NEU N) TO (W+ MU- N), W+ TO (MU+ NEU, E+ NEU, OR HDRNS)  2/74
M     C  BARISH 73 LOOKED FOR (NEU N) TO (W+ MU- N), W+ TO (MU+ NEU) AT NAL.  2/74
M     C  RESULT GIVEN FOR THREE ASSUMED BR.FRACS. W+ TO (LEPTON NEU)/ALL.     2/74
M     E  BERGESON 73 LOOKED AT ENERGY DISTR OF NEU-INDUCED MUON FLUX UNDER-   1/76
M     E  GROUND. SCALE INVARIANCE OF THE INELASTIC STRUCT FN ASSUMED.         1/76
M     U  BUSSER 74 IS CERN ISR EXPT. LOOKED FOR ELECTRONS OF LARGE            8/76
M     U  TRANSVERSE MOMENTUM. RESULT QUOTED ABOVE IS MODEL DEPENDENT.         8/76

C       W BOSON PRODUCTION CROSS SECTION (10**-36 CM**2)
C     A   0     6.0    OR LESS                ANKENBRAN 71 CNTR +- W TO(MU NEU)=1.0  2/74
C     A  ANKENBRANDT 71 LOOKED FOR (P N)TO(W HADRONS), W TO (MU NEJ) AT BNL.  2/74
C     A  THIS ASSUMES BR OF W TO MU NEU IS 1.  IN GENERAL THIS VALUE IS       2/74
C     A  6.0/BR, WHERE BR=(W TO MU NEU)/(W TO ALL).                           2/74

S       SCALAR BOSON MASS LIMITS (GEV)
S     C   0    10.0    OR MORE  CL=.90   CONVERSI  73 ASPK  0 E+E- FRASCATI      3/74
S     C  CONVERSI 73 LOOKED FOR QED VIOLATION IN E+E- SCATTERING AT 2.8 GEV   3/74
S     C  AND ASSUMED W BOSON MASS=10 GEV.  FOR MW=15 GEV, MS LIMIT= 6.5 GEV   3/74

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REFERENCES FOR INTERMEDIATE BOSON SEARCHES


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BERNARDI 65 NC 38 608          BERNARDINI,BIENLEIN,BOHM,DARDEL,+      (CERN)
BURNS    65 PRL 15 42          +GOULIANOS,HYMAN,LEDERMAN,LEE +   (COLU+BNL)
ANKENBRA 71 PR D3 2582         ANKENBRANDT,LARSEN,LEIPUNER+      (BNL+YALE)

BARISH   73 PRL 31 180         +BARTLETT,BUCHHOLZ,HUMPHREY+      (CIT+FNAL)
BERGESON 73 PRL 31 66          +CASSIDAY,HENDRICKS                    (UTAH)
CONVERSI 73 PL 46B 269         +D'ANGELO,GATTO,PAOLUZI                (ROMA)
BUSSER   74 PL 48B 371         +CAMILLERI,DI LELLA +      (CERN+COLJ+ROCK)
ABRAMOV  77 SJNP 25 41         +ANISIMOVA,BONDARENKO,GRIDASOV +       (SERP)
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QUARK SEARCHES

SEARCHES FOR INTEGRALLY CHARGED QUARKS APPEAR ALONG WITH OTHER SIMILAR SEARCHES IN 'OTHER NEW PARTICLE SEARCHES' SECTION BELOW.

Since the last edition, two more instances of charge ±1/3 have been claimed by the Stanford group (LARUE 79) using magnetic levitation of heat-treated niobium beads. There has as yet been no independent confirmation of the existence of free quarks.

The best searches for quarks in cosmic rays yield upper limits on the flux of quarks of about

Data Card Listings

For notation, see key at front of Listings.

Stable Particles

QUARK SEARCHES

10^{-11} cm^{-2} $ster^{-1}$ sec^{-1}. Cross-section upper limits established from proton accelerator experiments and calculations based on production models[1] imply that free quarks, if they exist, have a mass greater than about 5 GeV. Mass limits from photon and electron beam searches are slightly lower, but more reliable, depending only on the QED calculations for quark pair production. Limits on free quark concentrations in stable matter vary enormously depending on the source of matter and the technique.

The largely negative result of quark searches does not prove that free quarks do not exist, but indicates that they are hard to find. De Rujula, Giles, and Jaffe[2] have considered the question of unconfined quarks in a framework of a renormalizable, spontaneously broken version of QCD, and conclude that: (1) production cross sections are small, (2) interaction cross sections with nucleons are very large, and (3) the physical masses of quarks are probably very large. On this basis, primordial quarks would be expected to be non-integrally charged, superheavy nucleon complexes.

We group quark searches by experimental technique — proton beams, photon beams, neutrino beams, electron beams, cosmic rays, and stable matter. Proton beam experiments generally measure quark production cross sections (we quote these in section C), differential cross-section ratios (section AF), or differential cross sections (sections IC and D). The photon beam experiment measures cross section per equivalent quanta (section DC), and the neutrino experiment measures the ratio of quark events over total events (section NEU). Searches with electron beams may measure differential cross sections (section G) and set limits on the quark mass (section M). Cosmic ray experiments measure quark flux (section F), and searches in stable matter measure quark concentration (section RHO). Most of the accelerator and cosmic ray experiments have searched for fractionally charged particles, but some have searched for massive stable particles which would have low velocity. The latter searches are usually sensitive to a range of charges and may appear in the section below on Other New Particle Searches.

We have relied heavily on the review of L. W. Jones[3] for data prior to April 1977.

References

1. T. K. Gaisser and F. Halzen, Phys. Rev. D11, 3157 (1975).
2. A. de Rujula, R. C. Giles, and R. L. Jaffe, Phys. Rev. D17, 285 (1978).
3. L. W. Jones, Rev. Mod. Phys. 69, 717 (1977).


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C        QUARK PRODUCTICN CRCSS SECT. FROM PROTON BEAM EXPTS. (CM**2)
C          0  2.0E-34 OR LESS  CL=.90   BINGHAM   64  HBC Q= -1/3 M=.5-2.0GEV  3/77
C          0  1.0E-34 OR LESS  CL=.90   BINGHAM   64 HLBC Q= -2/3 M=.5-2.5GEV  3/77
C          0  2.0E-35 OR LESS           BLUM      64  HBC Q= -1/3 M=0-2.5GEV   3/77
C     Z    0  9.5E-36 OR LESS           HAGOPIAN  64  HBC Q= +1/3 M=.5-2.5GEV  3/77
C          0  1.0E-34 OR LESS           LEIPUNER  64 CNTR Q= -1/3 M=0-2.0GEV   3/77
C          0  4.0E-34 OR LESS           MORRISON  64  HBC Q= -1/3 M=.5-2.5GEV  3/77
C          0  1.0E-33 OR LESS           MORRISON  64  HBC Q= -2/3 M=.5-2.5GEV  3/77
C     W    0  2.0E-35 OR LESS           FRANZINI  65 CNTR Q= -2/3 M=0-2.5GEV   3/77
C     Y    0  3.2E-39 OR LESS  CL=.90   ALLABY    69 CNTR Q= -1/3 M=2GEV       1/76
C     Y    0  5.5E-38 OR LESS  CL=.90   ALLABY    69 CNTR Q= -2/3 M=2GEV       1/76
C     Y    0  1.8E-35 OR LESS  CL=.90   ALLABY    69 CNTR Q= +1/3 M=2GEV       1/76
C     Y    0  1.0E-35 OR LESS  CL=.90   ALLABY    69 CNTR Q= +2/3 M=2GEV       1/76
C     A    0  4.0E-37 OR LESS  CL=.90   ANTIPOV1  69 CNTR Q= -2/3 M=0-5GEV     2/74
C     A    0  3.0E-39 OR LESS  CL=.90   ANTIPOV2  69 CNTR Q= -1/3 M=4.5-5GEV   1/76
C     A    0  3.0E-37 OR LESS  CL=.90   ANTIPOV2  69 CNTR Q= -2/3 M=2-5GEV     1/76
C     V    0  1.0E-36 OR LESS  CL=.90   ANTIPOV   71 CNTR Q= -4/3 M=4GEV       1/76
C     B    0  3.0E-34 OR LESS           BOTT-BODE 72 CNTR Q=+-1/3 M=0-22GEV    2/74
C     B    0  6.0E-34 OR LESS           BOTT-BODE 72 CNTR Q=+-2/3 M=0-13GEV    2/74
C     P    0  1.0E-32 OR LESS  CL=.90   ALPER     73 SPEC Q=  2/3 M=4-24 GEV   1/76
C     P    0  1.0E-32 OR LESS  CL=.90   ALPER     73 SPEC Q=  4/3 M=4-24 GEV   1/76
C     L    0  1.0E-35 OR LESS           LEIPUNER  73 CNTR Q=  1/3 M=0-12GEV    2/74
C     L    0  1.0E-35 OR LESS           LEIPUNER  73 CNTR Q=  2/3 M=0-12GEV    2/74
C     L    0  5.0E-31 OR LESS           LEIPUNER  73 CNTR Q=  4/3 M=0-12GEV    2/74
C     N    0  5.0E-39 OR LESS  CL=.90   NASH      74 CNTR Q= -1/3 M=4- 9GEV    2/77
C     N    0  5.0E-38 OR LESS  CL=.90   NASH      74 CNTR Q= -2/3 M=4-11GEV    2/77
C     F    0  4.0E-35 OR LESS  CL=.90   FABJAN    75 CNTR Q=  1/3 M=0-20 GEV   1/77
C     F    0  8.0E-35 OR LESS  CL=.90   FABJAN    75 CNTR Q=  2/3 M=0-20 GEV   1/77
C     S    0  1.0E-35 OR LESS  CL=.90   BASILE1   78 SPEC Q=+-1/3 M=0-20 GEV   2/79*
C     X    0  1.0E-33 OR LESS  CL=.90   BASILE1   78 SPEC Q=+-1/3 M=0-26 GEV   2/79*
C     Z   HAGOPIAN 64 CROSS SECTION INFERRED FROM FLUX DATA.                   3/77
C     W   FRANZINI 65 CROSS SECTION INFERRED FROM FLUX DATA.                   3/77
C     Y   ALLABY 69 IS A CERN 27 GEV P+BE EXPT.  STUDIES MASSES 0-2.7GEV       1/76
C     Y   ASSUMING NN=NNQQ.  CROSS SECTIONS ASSUME ISOTROPIC PROD. IN CM.      1/76
C     Y   CROSS SECTIONS AT 2GEV ARE GIVEN HERE.  SEE FIG.9 FOR MASS DEPEN.    1/76
C     A   ANTIPOV1 69 IS A SERPUKHOV 70 GEV P EXPT.  MASS LIMIT FROM NN=NNQQ.  2/74
C     A   ANTIPOV1 69 AND ANTIPOV2 69 ARE SERPUKHOV 70GEV P EXPTS.  ANTIPOV2   1/76
C     A   GIVES RESULTS FOR M=2-5GEV ASSUMING NN-->NNQQ, HADRONIC OR LEPTONIC  1/76
C     A   QUARKS.  WE QUOTE TYPICAL VALUES.                                    1/76
C     V   ANTIPOV 71 IS A SERPUKHOV 70 GEV P+AL EXPT.  STUDIES DIQUARK MASSES  1/76
C     V   1.9-4.4GEV.  WE SHOW 4GEV VALUE.  SEE THEIR FIG.2 FOR MASS DEPEN.    1/76
C     B   BOTT-BODENHAUSEN 72 IS A CERN ISR 26+26 GEV P+P EXPERIMENT.          2/74
C     P   ALPER 73 IS CERN ISR 26+26 GEV P+P EXPT. ASSUMES ISOTROPIC C.M.      1/76
C     P   PRODUCTION.  SENSITIVE TO ANY Q>2/3.                                 1/76
C     L   LEIPUNER 73 IS AN NAL 300 GEV P EXPERIMENT.                          2/74
C     N   NASH 74 IS FNAL EXPT USING 200 AND 300 GEV PROTONS. SEE FIG 2,PG861  2/77
C     N   FOR OTHER MASS VALUES AND VARIOUS PRODUCTION MECHANISMS.             2/77
C     F   FABJAN 75 IS CERN ISR P+P EXPT.  INCLUDES RESULTS OF BOTT-BODE 72    1/77
C     F   EXPT.  RESULTS  ARE FOR ECM=53 GEV.                                  1/77
C     S   BASILE1 78 IS CERN-ISR EXPT WITH ECM=52.5 GEV.                       2/79*
C     X   THE ABOVE RESULT IS FOR ECM=62 GEV, FROM AN EARLIER EXP (BASILE 77)  2/79*

AF        QUARK PRODUCTION FLUX (FLUX QUARKS / FLUX CHARGED PARTICLES)
AF F       0  6.2E-10 OR LESS           FABJAN    75 CNTR    M=0-20 GEV        2/80*
AF    B    0  1.78E-9 OR LESS  CL=.90   BASILE    77 SPEC Q= +1/3 M=0-26GEV    1/78
AF    B    0  1.05E-9 OR LESS  CL=.90   BASILE    77 SPEC Q= -1/3 M=0-26GEV    1/78
AF    A    0  5.11E-11OR LESS  CL=.90   BASILE1   78 SPEC Q=+-1/3 M=0-21 GEV   2/79*
AF    O    0  4.E-11  OR LESS           BOZZOLI   79 CNTR    Q=-2/3, 1<M<3    12/79*
AF    O    0  2.E-11  OR LESS           BOZZOLI   79 CNTR    Q=-4/3, 2<M<6    12/79*
AF    O    0  3.E-11  OR LESS           BOZZOLI   79 CNTR    Q=+2/3, 1<M<3    12/79*
AF    O    0  3.E-10  OR LESS           BOZZOLI   79 CNTR    Q=+4/3, 2<M<6    12/79*
AF F      FABJAN 75 REPORTS BOTH FLUX AND CROSS SECTION (ABOVE)
AF    B   BASILE 77 IS A CERN-ISR PP EXP AT ECM=62.2 GEV COVERING PT UP TO 1   2/78
AF    B   GEV BASILE 77 FIND ONE QUARK CANDIDATE WITH M .LT. .169 GEV.         2/78
AF    B   THEY DO NOT CLAIM THIS AS A QUARK.                                   2/78
AF    A   BASILE 78 IS CERN-ISR EXPT WITH ECM=52.5 GEV.                        2/79*
AF    O   BOZZOLI 79 SEARCHED FOR QUARKS WITH LIFETIME > 1.E-8 SEC IN 200     12/79*
AF    O     GEV/C P BE INTERACTIONS USING RF SEPERATOR AS MASS SPECTOMETER.   12/79*

IC        QUARK INVARIANT PROD. CROSS SECT. FROM PROTON BEAMS  (CM**2/GEV**2)
IC    T    0  5.1E-39 OR LESS  CL=.90   ANTREASYA 77 SPEC Q= +1/3 M=0-6.3 GEV 11/77
IC    T    0  8.8E-39 OR LESS  CL=.90   ANTREASYA 77 SPEC Q= -1/3 M=0-6.3 GEV 11/77
IC    T    0  1.3E-39 OR LESS  CL=.90   ANTREASYA 77 SPEC Q= +2/3 M=0-8   GEV 11/77
IC    T    0  2.2E-39 OR LESS  CL=.90   ANTREASYA 77 SPEC Q= -2/3 M=0-8   GEV 11/77
IC    S    0  4. E-39 OR LESS  CL=.90   STEVENSON 79 CNTR Q=  2/3 M>5 GEV     12/79*
IC    S    0  5. E-38 OR LESS  CL=.90   STEVENSON 79 CNTR Q=  1/3 M>5 GEV     12/79*
IC    T   ANTREASYAN 77 LOOKS FOR HIGH TRANSVERSE MOM QUARKS IN 400 GEV P-CU  11/77
IC    T   INTERACTIONS AT FNAL.                                               11/77
IC    S   STEVENSON 79 IS 300 GEV P-CU EXPT AT FNAL, SENSITIVE TO PARTICLES   12/79*
IC    S   WITH LIFETIMES BETWEEN 2.5E-5 AND 1.E-3 SEC.                        12/79*

D         QUARK PROD. DIFF. CROSS SEC. FROM PRCTON BEAM EXPTS.  (CM**2/SR-GEV)
D     D    0  1.5E-36 OR LESS           DORFAN    65 CNTR BE TARG  M=3-7GEV    2/74
D     D    0  3.0E-36 OR LESS           DORFAN    65 CNTR FE TARG  M=3-7GEV    2/74
D     Y    0  7.2E-39 OR LESS  CL=.90   ALLABY    69 CNTR Q=-1/3  THETA= 0 MR  1/76
D     Y    0  5.2E-38 OR LESS  CL=.90   ALLABY    69 CNTR Q=-2/3  THETA=6.5MR  1/76
D     Y    0  2.6E-35 OR LESS  CL=.90   ALLABY    69 CNTR Q=+1/3  THETA=44 MR  1/76
D     Y    0  1.3E-35 OR LESS  CL=.90   ALLABY    69 CNTR Q=+2/3  THETA=44 MR  1/76
D     A    0  7.0E-38 OR LESS  CL=.90   ANTIPOV2  69 CNTR Q=-1/3    M=0-5GEV   1/76
D     A    0  4.0E-38 OR LESS  CL=.90   ANTIPOV2  69 CNTR Q=-2/3    M=0-2.5GEV 1/76
D     V    0  1.6E-36 OR LESS  CL=.90   ANTIPOV   71 CNTR Q=-4/3  THETA=47 MR  1/76
D     V    0  3.8E-36 OR LESS  CL=.90   ANTIPOV   71 CNTR Q=-4/3  THETA=47 MR  1/76
D     N    0  5.6E-36 OR LESS  CL=.90   NASH      74 CNTR Q=-1/3               2/77
D     N    0  5.0E-35 OR LESS  CL=.90   NASH      74 CNTR Q=-2/3    M GT 1.76  2/77
D     N    0  8.5E-35 OR LESS  CL=.90   NASH      74 CNTR Q=-2/3    M LT 1.76  2/77
D     L    0  1.6E-33 OR LESS  CL=.90   ALBROW    75 SPEC Q=+-4/3  M=5-20 GEV  1/77
D     J    0  5.0E-34 OR LESS  CL=.90   JOVANOVIC 75 CNTR Q=1/3  M=7-15 GEV    2/76
D     J    0  2.0E-34 OR LESS  CL=.90   JOVANOVIC 75 CNTR Q=1/3  M=15-26 GEV  11/75
D     J    0  1.3E-34 OR LESS  CL=.90   JOVANOVIC 75 CNTR Q=2/3  M=10-26 GEV  11/75
D     J    0  8.0E-35 OR LESS  CL=.90   JOVANOVIC 75 CNTR Q=4/3  M=10-26 GEV  11/75
D     B    0  3.9E-36 OR LESS  CL=.90   BALDIN    76 CNTR Q=-2/3  M=1.4-6 GEV  1/77
D     B    0  2.0E-36 OR LESS  CL=.90   BALDIN    76 CNTR Q=-4/3  M=2.7-12GEV  1/77
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Stable Particles

Data Card Listings

QUARK SEARCHES

For notation, see key at front of Listings.

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D     D  DORFAN 65 IS A 30 GEV/C P EXPERIMENT AT BNL.   V=.18-.995             2/74
D     Y  SEE FOOTNOTE Y IN SUBSECTION C ABOVE.                                 2/76
D     A  SEE FOOTNOTE A IN SUBSECTION C ABOVE.                                 2/76
D     V  FIRST ANTIPOV 71 VALUE IS FOR M=1.9-2.3,2.7-4.4GEV, SECOND IS FOR     1/76
D     V  M=2.3-2.7GEV.  SEE ALSO NOTE V IN SECTION C ABOVE.                    1/76
D     N  NASH 74 IS FNAL EXPT USING 200 AND 300 GEV PROTONS.  VALUES ARE FOR   2/77
D     N  A 1MRAD LAB PROD. ANGLE AND OUTGOING MOMENTUM AT MAX OF FOUR BODY     2/77
D     N  PHASE SPACE FOR QUARK-PAIR PROD.  SEE TABLE I PG. 860 FOR OTHER       2/77
D     N  LIMITS.                                                               2/77
D     L  ALBROW 75 IS A CERN ISR EXPT WITH ECM=53 GEV. THETA=40 MR. SEE        1/77
D     L  FIG. 5 FOR MASS RANGES UP TO 25 GEV.                                  1/77
D     J  JCVANOVICH 75 FIG.4 COVERS RANGES Q=1/3 TO 2 AND M=3 TO 26 GEV.      11/75
D     J  THIS IS A CERN ISR 26+26, 22+22 GEV P+P EXPERIMENT.                   2/76
D     B  BALDIN 76 IS A 70 GEV SERP EXP.  VALUES ARE PER AL NUCLEUS AT         1/77
D     B  THETA=0.  ASSUMES STABLE PARTICLE INTERACTING WITH MATTER IN SAME     1/77
D     B  MANNER AS ANTIPROTON.                                                 1/77

DG      QUARK PROD. DIFF. CROSS SEC. FROM PHOTOPROD. (CM**2/SR-EQUIV.QUANTA)
DG    G      5.0E-35 OR LESS  CL=.90   GALIK      74 CNTR    THETA=1.2,7 DEG. 11/76
DG    G  GALIK 74 IS 20 GEV(MAX) GAMMA CU EXPT. USING SLAC 20 GEV SPTRMETER. 11/76

NEU     QUARK PRODUCTION IN NEUTRINO BEAMS (QUARK EVS./TOTAL EVS.)            7/79*
NEU       0 (5.0E-3) OR LESS  CL=.90   BASILE2    78 CNTR NUMU BEAM AT SPS     7/79*

M       LIMIT CN QUARK MASS FROM ELECTRON BEAMS          (GEV/C**2)
M        *LEP QUARK  INDICATES LEPTONIC QUARK
M        *STR QUARK  INDICATES STRONG QUARK
M               .85   OR MORE  CL=.99   BATHOW    67 CNTR Q=1/3   *LEP QUARK   3/77
M               .90   OR MORE  CL=.99   BATHOW    67 CNTR Q=2/3   *LEP QUARK   3/77
M               .70   OR MORE  CL=.90   FOSS      67 CNTR Q=1/3   *LEP QUARK   3/77
M               .84   OR MORE  CL=.90   FOSS      67 CNTR Q=2/3   *LEP CUARK   3/77
M              1.0    OR MORE           BELLAMY   68 CNTR Q=1/3   *LEP QUARK   3/77
M              1.5    OR MORE           BELLAMY   68 CNTR Q=2/3   *LEP CUARK   3/77
M              0.5    OR MORE           BELLAMY   68 CNTR Q=1/3   *STR QUARK   3/77
M               .75   OR MORE           BELLAMY   68 CNTR Q=2/3   *STR QUARK   3/77
M     G        3.6    OR MORE  CL=.90   GALIK     74 CNTR Q=1/3   *STR CUARK   7/76
M     G        4.5    OR MORE  CL=.90   GALIK     74 CNTR Q=2/3   *STR QUARK   7/76
M     G        1.4    OR MORE  CL=.90   GALIK     74 CNTR Q=1/3   *LEP QUARK   7/76
M     G        1.8    OR MORE  CL=.90   GALIK     74 CNTR Q=2/3   *LEP QUARK   7/76
M     G  FIRST TWO MASS LIMITS ARE FOR STRONGLY INTERACTING QUARKS,INFERRED   7/76
M     G  FROM CROSS-SEC LIMITS USING DRELL MODEL. LAST TWO ARE FOR LEPTONIC   7/76
M     G  QUARKS. EXPT USES PHOTOPRODUCTION ON COPPER.                          7/76

F       QUARK FLUX FROM COSMIC RAY EXPERIMENTS  (NUMBER/CM**2-SR-SEC)
F        *TD IN THE RIGHT HAND COLUMNS INDICATES A SEARCH FOR MASSIVE
F           QUARKS USING TIME DELAY AFTER AIR SHOWERS, SENSITIVE TC A RANGE
F           OF CHARGES
F        *AS IN THE RIGHT HAND COLUMNS INDICATES A SEARCH IN AIR SHOWERS
F        ALL SEARCHES ARE AT SEA LEVEL UNLESS OTHERWISE INDICATED
F          0 1.6E-8    OR LESS  CL=.90   BOWEN     64 CNTR Q=-1/3  ALT=2750M    3/77
F          0 2.0E-7    OR LESS  CL=.90   SUNYAR    64 CNTR Q=1/3                3/77
F          0 8.7E-9    OR LESS  CL=.90   DELISE    65 CNTR Q=1/3   ALT=2750M    3/77
F          0 1.8E-8    OR LESS  CL=.90   DELISE    65 CNTR Q=2/3   ALT=2750M    3/77
F          0 5.0E-8    OR LESS  CL=.90   MASSAM    65 CNTR Q=2/3                3/77
F     V    0 1.4E-10   OR LESS           BARTCN    66 CNTR Q=2/3                3/77
F          0 1.5E-9    OR LESS  CL=.90   BUHLER-BR 66 CNTR Q=1/3   ALT= 450M    3/77
F          0 1.4E-9    OR LESS  CL=.90   BUHLER-BR 66 CNTR Q=2/3   ALT= 450M    3/77
F          0 2.6E-9    OR LESS           KASHA     66 CNTR Q=1/3                3/77
F          0 2.1E-9    OR LESS           KASHA     66 CNTR Q=2/3                3/77
F          0 4.5E-10   OR LESS  CL=.90   LAMB      66 CNTR Q=1/3                3/77
F          0 1.6E-9    OR LESS  CL=.90   LAMB      66 CNTR Q=2/3                3/77
F     W    0 1.4E-10   OR LESS           BARTON    67 CNTR Q=2/3                3/77
F     Q    0 1.6E-7    OR LESS           BUHLER-1  67 CNTR Q=4/3   ALT= 450M    3/77
F     Q    0 4.5E-10   OR LESS  CL=.90   BUHLER-2  67 CNTR Q=1/3   ALT= 450M    3/77
F     Q    0 1.7E-10   OR LESS           BUHLER-2  67 CNTR Q=2/3   ALT= 450M    3/77
F          0 1.7E-10   OR LESS  CL=.90   GOMEZ     67 CNTR Q=1/3                3/77
F          0 3.4E-10   OR LESS  CL=.90   GCMEZ     67 CNTR Q=2/3                3/77
F          0 2.0E-9    OR LESS  CL=.90   KASHA     67 CNTR Q=2/3                3/77
F     C    0 3.0E-10   OR LESS           BJORNBOE  68 CNTR M=5GEV OR MORE *TD   2/74
F     R    0 1.8E-10   OR LESS  CL=.90   BRIATORE  68 CNTR Q=1/3                5/76
F     R    0 1.8E-10   OR LESS  CL=.90   BRIATCRE  68 CNTR Q=2/3                5/76
F     R    0 3.7E-8    OR LESS  CL=.90   BRIATORE  68 CNTR Q=4/3                5/76
F     Y    0 2.2E-8    OR LESS           FRANZINI  68 CNTR V=.5-.9C  M=2GEV UP  2/74
F          0 6.6E-11   OR LESS  CL=.95   GARMIRE   68 CNTR Q=1/3                3/77
F          0 8.8E-11   OR LESS  CL=.95   GARMIRE   68 CNTR Q=2/3                3/77
F          0 3.1E-10   OR LESS  CL=.90   HANAYAMA  68 CNTR Q=1/3                3/77
F          0 2.4E-8    OR LESS  CL=.95   KASHA1    68 OSPK V=.5-.75C M=5-15GEV  2/74
F          0 1.2E-10   OR LESS  CL=.90   KASHA2    68 CNTR Q=2/3                3/77
F          0 1.3E-10   OR LESS  CL=.90   KASHA3    68 CNTR Q=4/3                3/77
F     Z    0 5.0E-11   OR LESS           CAIRNS    69 CC   Q=2/3                3/77
F     F    0 5.0E-11   OR LESS  CL=.90   FUKUSHIMA 69 CNTR Q=1/3                2/74
F     F    0 7.5E-10   OR LESS  CL=.90   FUKUSHIMA 69 CNTR Q=2/3                2/74
F    M     1  EVENT CLAIMED              MCCUSKER  69 CC   Q=2/3          *AS   2/74
F          0 5.0E-10   OR LESS           BOSIA     70 CNTR Q=1/3   ALT=3500M    1/78
F          0 2.5E-10   OR LESS           BOSIA     70 CNTR Q=2/3   ALT=3500M    1/78
F    U     1  EVENT CLAIMED              CHU       70 HLBC                *AS   5/76
F          0 1.9E-9    OR LESS  CL=.90   FAISSNER  70 CNTR Q=1/3                3/77
F          0 9.8E-11   OR LESS  CL=.90   KRIDER    70 CNTR Q=1/3   ALT=750M     3/77
F          0 1.6E-10   OR LESS  CL=.90   KRIDER    70 CNTR Q=2/3   ALT=750M     3/77
F          0 1.3E-10   OR LESS  CL=.90   CHIN      71 CNTR Q=1/3                3/77
F          0 5.7E-11   OR LESS  CL=.90   CHIN      71 CNTR Q=1/3   ALT=2770M    3/77
F          0 3.0E-10   OR LESS  CL=.90   CLARK     71 CC   Q=1/3          *AS   3/77
F          0 3.0E-11   OR LESS  CL=.90   CLARK     71 CC   Q=2/3          *AS   3/77
F          0 1.0E-10   OR LESS  CL=.90   HAZEN     71 CC   Q=1/3,2/3      *AS   2/77
F          0 4.1E-10   OR LESS           BEUCHAMP  72 CNTR Q=4/3   ALT=2750M    3/77
F          0 1.0E-10   OR LESS  CL=.90   BOHM      72 CNTR Q=1/3          *AS   2/74
F          0 1.0E-10   OR LESS  CL=.90   BOHM      72 CNTR Q=2/3          *AS   2/74
F          0 8.3E-11   OR LESS  CL=.90   COX       72 ELEC Q=1/3   ALT=2750M    3/77
F          0 9.6E-11   OR LESS  CL=.90   COX       72 ELEC Q=2/3   ALT=2750M    3/77
F          0 2.2E-10   OR LESS  CL=.90   CROUCH    72 CNTR Q=2/3                3/77
F     X    0 3.0E-8    OR LESS           DARDO     72                     *TD   3/77
F          0 4.0E-9    OR LESS  CL=.95   EVANS     72 CC   Q=1/3          *AS   1/77
F          0 1.5E-9    OR LESS           TONWAR    72 CNTR M.GT.10GEV     *TD   3/77
F          0 8.0E-11   OR LESS           ASHTON    73 CNTR Q=1/3          *AS   3/77
F     H    0 1.7E-8    OR LESS  CL=.90   HICKS     73 CNTR Q=1/3 .              1/76
F     H    0 1.7E-8    OR LESS  CL=.90   HICKS     73 CNTR Q=2/3                1/76
F          0 1.0E-7    OR LESS  CL=.90   CLARK     74 CC   Q=1/6          *AS   1/77
F          0 7.0E-10   OR LESS  CL=.90   CLARK     74 CC   Q=1/4          *AS   1/77
F          0 8.0E-11   OR LESS  CL=.90   CLARK     74 CC   Q=1/3          *AS   1/77
F          0 2.0E-11   OR LESS  CL=.90   CLARK     74 CC   Q=2/3          *AS   1/77
F     K    0 3.0E-10   OR LESS  CL=.95   KIFUNE    74 CNTR Q=1/3                7/76
F          0 1.2E-11   OR LESS  CL=.90   HAZEN     75 CC   Q=1/3          *AS   7/76
F          0 7.0E-11   OR LESS  CL=.90   KRISOR    75 CNTR Q=1/3                3/77
F          0 5.0E-11   OR LESS  CL=.90   KRISOR    75 CNTR Q=2/3  GAMMA = 10    3/77
F          0 1.5E-10   OR LESS  CL=.90   KRISOR    75 CNTR Q=2/3  GAMMA GT1000  3/77
F          0 1.0E-9    OR LESS           BRIATORE  76 ELEC                *TD   1/77
F     O    3  EVENTS CLAIMED             YOCK      78 CNTR                      2/79*
F     V  BARTON 66 HAD 220000 G/CM**2 EXTRA SHIELDING                          3/77
F     W  BARTON 67 HAD 6000 G/CM**2 EXTRA SHIELDING                            3/77
F     Q  BUHLER-1 67 AND BUHLER-2 67 HAD 760 G/CM**2 EXTRA SHIELDING           3/77
F     C  BJORNBOE 68 -TWO EXPERIMENTS HAVING 1650 AND 3600 G/CM**2 SHIELDING   3/77
F     R  BRIATORE 68 SEARCHES FOR LEPTONIC QUARKS WITH 6300 G/CM2 SHIELDING    3/77
F     R  BRIATORE 68 GIVES (1.1+-1.8)E-10 FOR Q=4/3  . WE CONV. TO CL=.90      3/77
F    Z   CAIRNS 69 OBSERVED 4 POSSIBLE QUARK CANDIDATES                        3/77
F     Y  FRANZINI 68 MEASURES VELOCITY DIRECTLY BY TOF                         3/77
F     F  FUKUSHIMA 69 DOES NOT RULE OUT QUARKS HEAVIER THAN 10 GEV.            7/76
F    M   MC CUSKER 69 CLAIMS 1 CANDIDATE.   LATER SIMILAR EXPTS. SEE NONE.     2/74
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F     U  Q=2/3 IF MASS LT 6.5 GEV, Q=1/3 IF MASS = 8 GEV.                      5/76
F     U  COULD BE AN EARLY-TIME NORMALLY CHARGED COSMIC RAY. SEE ALLISON 70.   2/77
F     X  DARDO 72 HAD 7000 G/CM**2 EXTRA SHIELDING                             3/77
F     H  HICKS 73 LOOKED AT LARGE ZENITH ANGLES, THUS USING THE ATMOSPHERE     1/76
F     H  AS AN EXTENDED FILTER FOR HADRONIC QUARKS. THEIR SEARCH PUTS AN       1/76
F     H  UPPER LIMIT ON LEPTONIC QUARK FLUX IN COSMIC RAYS.                    1/76
F     K  KIFUNE 74 LOOKED AT LARGE ZENITH ANGLES. FROM THEIR FLUX LIMIT,THEY   7/76
F     K  GET A LOWER LIMIT ON QUARK MASS OF 20 GEV.                            7/76
F     O  YOCK 78 EVENTS HAVE TAU > 10**-8 SEC, CHARGES OF +-.70,+-.68,+-.42,   2/79*
F     O  AND MASSES >4.4, 4.8, AND 20 GEV RESPECTIVELY.  MEASURES BETA AND     2/79*
F     O  DE/DX IN OSPK-SCINTILATOR COSMIC RAY TELESCOPE.  IF TAKEN AS QUARK,   2/79*
F     O  THE OBSERVED FLUX WOULD BE 2.4E-9.                                    7/79*

RHO     QUARK CONCENTRATION IN MATTER (QUARKS PER NUCLEON)
RHO  S    0 1.0E-22   OR LESS            HILLAS     59                         3/77
RHO  R    0 1.0E-10   OR LESS            BENNETT    66 SOLAR SPECTRUM          3/77
RHO       0 1.0E-17   OR LESS            CHUPKA     66 METORITES               3/77
RHO       0 1.0E-16   OR LESS            GALLINARO 66    GRAPHITE LEVITOMETER  3/77
RHO       0 4.0E-19   OR LESS            STOVER     67 IRON LEVITOMETER        2/74
RHO       0 1.0E-17   OR LESS            BRAGINSKI 68 GRAPHITE LEVITOMETER     3/77
RHO       0 1.0E-20   OR LESS            RANK       68 OIL DROPS               3/77
RHO  T    0 1.0E-18   OR LESS            RANK       68 SEA WATER               3/77
RHO  T    0 1.0E-17   OR LESS            RANK       68 SEA SALT, ETC.          3/77
RHO  T    0 1.0E-18   OR LESS            RANK       68 LAKE WATER              3/77
RHO  V    0 1.0E-24   OR LESS            COCK       69  SEAWATER               2/74
RHO  V    0 1.0E-23   OR LESS            COOK       69  ROCK SAMPLES           2/74
RHO  V    0 1.0E-23   OR LESS            COOK       69 LAVA                    3/77
RHO  V    0 5.0E-23   OR LESS            COOK       69 LIMESTONE               3/77
RHO       0 1.0E-15   OR LESS            ELBERT     70 ICN SPECTROMETER        3/77
RHO       0 5.0E-19   OR LESS            MORPURGO   70 GRAPHITE LEVITOMETER    3/77
RHO  Z    0 1.0E-21   OR LESS            STEVENS    76 DEEP OCEAN SEDIMENT     3/77
RHO  Z    0 1.0E-22   OR LESS            STEVENS    76 LUNAR SOIL              3/77
RHO  B    0 3.0E-18   OR LESS            BLAND      77 TUNGSTEN BEADS          8/77
RHO       0 3.0E-21   OR LESS            GALLINARO 77 IRON LEVITOMETER         7/77
RHO  L    1 EVENT  Q=+0.337+-.009        LARUE      77 NIOBIUM-TUNGSTEN LEVITOM  7/77
RHO  L    1 EVENT  Q=-0.331+-.070        LARUE      77 NIOBIUM-TUNGSTEN LEVITOM  7/77
RHO  M    0(2. E-19) OR LESS             MULLER     77 CNTR 2.5<M<7.7 GEV/C2  12/79*
RHO  M    0(1. E-13) OR LESS             MULLER     77 CNTR FOR M<.3          12/79*
RHO  M    0(9. E-15) OR LESS             MULLER     77 CNTR .3<M<2.5 GEV/C2   12/79*
RHO       0(5.0E-28) OR LESS             OGORODNIK 77 SEAWATER                12/79*
RHO       0(5.0E-27) OR LESS             OGORODNIK 77 SEDIMENT,LAVA           12/79*
RHO  O    0 5.0E-15   OR LESS            BOYD       78          TUNGSTEN IONS   8/78*
RHO  Y    0(5.0E-16) OR LESS  CL=.67     BOYD2      78 HYDROGEN                1/79*
RHO  P    0 5.6E-15   OR LESS            PUTT       78 TUNSTEN BEADS           2/79*
RHO  H    0 1.0E-22   OR LESS            SCHIFFER   78 NIOBIUM, TUNGSTEN+IRON  2/79*
RHO  D    0(6.4E-16) OR LESS  CL=.67     BOYD       79 HELIUM                 12/79*
RHO       2 EVENTS Q=+0.345+-.035        LARUE      79 NIOBIUM BALL LEVITATION  7/79*
RHO                Q=+0.304+-.040        LARUE      79 NIOBIUM BALL LEVITATION  7/79*
RHO          4.7E-21 QUARKS/NUCLEON      LARUE      79 NIOBIUM BALL LEVITATION  7/79*
RHO  S  HILLAS 59 WAS INSENSITIVE TO QUARKS ACCORDING TO SUNYAR 64.            3/77
RHO  R  BENNETT 66 LIMIT INFERRED BY JONES 76.                                 3/77
RHO  T  RANK 68 USES U.V. SPECTROSCOPY.                                        3/77
RHO  V  COOK 69 USES MOLECULAR BEAMS.                                          3/77
RHO  Z  STEVENS 76 USES AN ION SPECTROMETER.                                   3/77
RHO  B  BLAND 77 IS A MILLIKAN OIL-DROP TYPE EXPT USING TUNSTEN PARTICLES.     8/77
RHO  B  NO FRACTIONAL CHARGE WAS FOUND ON A TOTAL SAMPLE OF 3.07E-7 GRAMS      8/77
RHO  L  LARUE 77 SEES RESIDUAL CHARGE LISTED ABOVE TRANSFERRED TO A            7/77
RHO  L  NIOBIUM BALL FROM A TUNGSTEN SUBSTRATE, CORRESPONDING TO A DENSITY     7/77
RHO  L  OF 1.E-23.                                                             7/77
RHO  M  MULLER 77 SEARCHES FOR CHARGE 1 QUARKS IN HYDROGEN USING A            12/79*
RHO  M  CYCLOTRON AS A MASS SPECTOGRAPH.                                      12/79*
RHO  C  BOYD 78 USES VAN-DE-GRAFF AS MASS SPECTOMETER TO SEARCH FOR Q=1/3      8/78*
RHO  Y  BOYD2 78 USES VAN-DE-GRAFF AS MASS SPECTOMETER TO SEARCH FOR Q=1       1/79*
RHO  Y  WITH MASS < 1.75 GEV.                                                  1/79*
RHO  Y  STABLE CHARGE 1 QUARKS WITH MASS < 1.75 GEV.                           1/79*
RHO  P  PUTT 78 IS A MILIKAN OIL-DROP TYPE EXPT. RESULT APPLIES TO Q>.2.       2/79*
RHO  H  SCHIFFER 78 LOOKS FOR QUARKS ACCELERATED BY A 1 MEV ELECTROSTATIC      2/79*
RHO  H  FIELD ONTO A SI DETECTOR FROM HEATED W, FE AND NB FILAMENTS.           2/79*
RHO  D  BOYD 79 USES HE BEAM WITH A VAN-DE-GRAFF AS MASS SPECTROMETER.        12/79*

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REFERENCES FOR QUARK SEARCHES


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HILLAS    59 NATURE 184 B92     HILLAS,CRANSHAW                          (AERE)

BINGHAM   64 PL 9 201           +DICKINSON,DIEBOLD,KOCH,LEITH+   (CERN+EPOL)
BLUM      64 PRL 13 353A        +BRANDT,COCCONI,CZYZEWSKI,DANYSZ+     (CERN)
BOWEN     64 PRL 13 728         BOWEN,DELISE,KALBACH,MORTARA          (ARIZ)
HAGOPIAN  64 PRL 13 280         +SELOVE,EHRLICH,LEBOY,LANZA,RAHM+(PENN+BNL)
LEIPUNER  64 PRL 12 423         LEIPUNER,CHU,LARSEN,ADAIR         (BNL+YALE)
MORRISON  64 PL 9 199           MORRISON                              (CERN)
SUNYAR    64 PR 136B 1157       SUNYAR,SCHWARZSCHILD,CCNNORS           (BNL)

DELISE    65 PR 140B 458        DELISE,BOWEN                          (ARIZ)
DORFAN    65 PRL 14 999         +EADES,LEDERMAN,LEE,TING              (CCLU)
FRANZINI  65 PRL 14 196         +LEONTIC,RAHM,SAMIOS,SCHWARTZ     (BNL+CCLU)
MASSAM    65 NC 40A 589         MASSAM,MULLER,ZICHICHI                (CERN)

BARTCN    66 PL 21 360          BARTON,STOCKEL                        (NPOL)
BENNETT   66 PRL 17 1196        W.R.BENNETT                           (YALE)
BUHLER-B  66 NC 45A 520         BUHLER-BROGLIN,FORTUNATO,MASSAM+      (CERN)
CHUPKA    66 PRL 17 60          CHUPKA,SCHIFFER,STEVENS                (ANL)
GALLINAR  66 PL 23 609          GALLINARO,MORPURGO                    (GENO)
KASHA     66 PR 150 1140        KASHA,LEIPUNER,ADAIR              (BNL+YALE)
LAMB      66 PRL 17 1068        LAMB,LUNDY,NOVEY,YOVANOVITCH           (ANL)

BARTON    67 PRSL 90 87         BARTON                                (NPOL)
BATHOW    67 PL 25B 163         BATHOW,FREYTAG,SCHULZ,TESCH           (DESY)
BUHLER-1  67 NC 49A 209         BUHLER-BROGLIN,FORTUNATO,MASSAM+      (CERN)
BUHLER-2  67 NC 51A 837         BUHLER-BROGLIN,DALPIAZ,MASSAM,ZICHICH(CERN)
FOSS      67 PL 25B 166         +GARELICK,HOMMA,LOBAR,OSBORNE,UGLUM    (MIT)
GOMEZ     67 PRL 18 1022        +KOBRAK,MOLINE,MULLINS,ORTH,VANPUTTEN+(CIT)
KASHA     67 PR 154 1263        +LEIPUNER,WANGLER,ALSPECTOR,ADAIR(BNL+YALE)
STOVER    67 PR 164 1599        +MORAN,TRISCHKA                       (SYRA)

BELLAMY   68 PR 166 1391        +HOFSTADTER,LAKIN,PERL,TONER     (STAN+SLAC)
BJORNBOE  68 NC B53 241         +DAMGARD,HANSEN,CHATTERJEE+      (BOHR+BERN)
BRAGINSK  68 JETP 27 51         BRAGINSKII,ZELDOVICH,MARTYNOV         (MOSU)
BRIATORE  68 NC 57A 850         +CASTAGNOLI,BOLLINI,MASSAM+      (TORI+CERN)
FRANZINI  68 PRL 21 1013        FRANZINI,SHULMAN                      (COLU)
GARMIRE   68 PR 166 1280        GARMIRE,LEONG,SREEKANTAN               (MIT)

HANAYAMA  68 CJP 46 S734        +HARA,HIGASHI,KITAMURA,MIONO+         (OSAK)
KASHA1    68 PR 172 1297        +STEFANSKI                        (BNL+YALE)
KASHA2    68 PRL 20 217         KASHA,LARSEN,LEIPUNER,ACAIR       (BNL+YALE)
KASHA3    68 CJP 46 S730        KASHA,LARSEN,LEIPUNER,ADAIR       (BNL+YALE)
RANK      68 PR 176 1635        D.M.RANK                              (MICH)

ALLABY    69 NC 64A 75          +BIANCHINI,DIDDENS,DOBINSON,HARTUNG+ (CERN)
ANTIPOV1  69 PL 29B 245         +KARPOV,KHROMOV,LANDSBERG,LAPSHIN+    (SERP)
ANTIPOV2  69 PL 30B 576         +BOLOTOV,DEVISHEV,DEVISHEVA,ISAKOV+   (SERP)
CAIRNS    69 PR 186 1394        +MCCKUSKER,PEAK,WOOLCOTT            (SYDNEY)
COOK      69 PR 188 2092        +DEPASQUALI,FRAUENFELDER,PEACOCK +     (ILL)
FUKUSHIM  69 PR 178 2058        FUKUSHIMA,KIFUNE,KONDO,KOSHIBA+       (TOKY)
MCCUSKER  69 PRL 23 658         MCCUSKER,CAIRNS                     (SYDNEY)
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

MAGNETIC MONOPOLE, CHARM SEARCHES


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BOSIA     70 NC 66A 167        G.BOSIA,L.BRIATORE                        (TORI)
CHU       70 PRL 24 917        CHU,KIM,BEAM,KWAK                (OSU+ROSE+KANS)
   ALSO   70 PRL 25 550        ALLISON,DERRICK,HUNT,SIMPSON,VOYVODIC (ANL)
ELBERT    70 NP B20 217        +ERWIN,HERB,NIELSEN,PETRILAK,WEINBERG(WISC)
FAISSNER  70 PRL 24 1357       +HOLDER,KRISOR,MASON,SAWAF,UMBACH      (AACH)
KRIDER    70 PR D1 835         KRIDER,BOWEN,KALBACH                   (ARIZ)
MORPURGO  70 NIM 79 95         MORPURGO,GALLINARO,PALMIERI            (GENO)

ANTIPOV   71 NP B27 374        +KACHANOV,KUTJIN,LANDSBERG,LEBEDEV + (SERP)
CHIN      71 NC 2A 419         CHIN,HANAYAMA,HARA,HIGASHI,TSUJI       (OSAK)
CLARK     71 PRL 27 51         +ERNST,FINN,GRIFFIN,HANSEN,SMITH+ (LLL+LBL)
HAZEN     71 PRL 26 582        W.E.HAZEN                              (MICH)

BEUCHAMP  72 PR D6 1211        BEUCHAMP,BOWEN,COX,KALBACH             (ARIZ)
BOHM      72 PRL 28 326        +DIEMONT,FAISSNER,FASOLD,KRISOR+       (AACH)
BOTT-BOD  72 PL 40B 693        BOTT-BODENHAUSEN,CALDWELL+        (CERN+MPIM)
COX       72 PR D6 1203        COX,BEUCHAMP,BOWEN,KALBACH             (ARIZ)
CROUCH    72 PR D5 2667        CROUCH,MORI,SMITH                      (CASE)
DARDO     72 NC 9A 319         DARDO,NAVARRA,PENENGO,SITTE            (TORI)
EVANS     72 PRSE A70 143      +FANCEY,MUIR,WATSON               (EDIN+LEED)
TONWAR    72 JPA 5 569         TONWAR,NARANAN,SREEKANTAN              (TATA)

ALPER     73 PL 46B 265          (CERN+LIVP+LUND+BOHR+RHEL+STOH+BERG+LOUC)
ASHTON    73 JPA 6 577         ASHTON,COOPER,PARVARESH,SALEH          (DURH)
HICKS     73 NC 14A 65         +FLINT,STANDIL                         (MANI)
LEIPUNER  73 PRL 31 1226       +LARSEN,SESSOMS,SMITH,WILLIAMS+  (BNL+YALE)

CLARK     74 PR D10 2721       +FINN,HANSEN,SMITH                      (LLL)
GALIK     74 PR D9 1856        +JORDAN,RICHTER,SEPPI,SIEMANN + (SLAC+FNAL)
KIFUNE    74 JPSJ 36 629       +HIEDA,KUROKAWA,TSUNEMOTO,KIMURA+(TOKY+KEK)
NASH      74 PRL 32 858        +YAMANOUCHI,NEASE,SCULLI    (FNAL+CORN+NYU)

ALBROW    75 NP B97 189        +BARBER,BENZ+(CERN+DARE+FOM+LANC+MCHS+UTRE)
FABJAN    75 NP B101 349       +GRJHN,PEAK,SAULI,CALDWELL+       (CERN+MPIM)
HAZEN     75 NP B95 189        +HODSON,WINTERSTEIN,GREEN,KASS+ (MICH+LEED)
JOVANOVI  75 PL 56B 105        JOVANOVICH+ (MANI+AACH+CERN+GENO+HARV+TORI)
KRISOR    75 NC 27A 132        KRISOR                                 (AACH)

BALDIN    76 SJNP 22 264       +VERTOGRADOV,VISHNEVSKII,GRISHKEVICH+(JINR)
BRIATORE  76 NC 31A 553        +DARDO,PIAZZOLI,MANNOCCHI+ (LCGT+FRAS+FREI)
STEVENS   76 PR D14 716        +SCHIFFER, CHUPKA                       (ANL)

ANTREASY  77 PRL 39 513        ANTREASYAN,COCCONI,CRONIN,FRISCH+(EFI+PRIN)
BASILE    77 NC 40A 41         +CARA ROMEO,CIFARELLI,GIUSTI+     (CERN+BGNA)
BLAND     77 PRL 39 369        +BOCOBO,EUBANK,ROYER         (SAN FRAN STATE)
GALLINAR  77 PRL 38 1255       GALLINARO,MARINELLI,MORPURGO           (GENO)
LARUE     77 PRL 38 1011       +FAIRBANK,HEBARD                       (STAN)
MULLER    77 SCIENCE 196 521   MULLER,ALVAREZ,HOLLEY+STEPHENSON        (LBL)
OGORODNI  77 JETP 45 857       OGORODNIKOV,SAMOILCV,SOLNTSEV          (KIAE)

BASILE1   78 NC 45A 171        +CARAROMEO,CIFARELLI,CONTIN +     (CERN+BGNA)
BASILE2   78 NC 45A 281        +CARAROMEO,CIFARELLI,CONTIN+      (CERN+BGNA)
BOYD      78 PRL 40 216        +ELMORE,MELISSINOS,SUGARBAKER          (ROCH)
BOYD2     78 PL 72B 484        +ELMORE,NITZ,OLSEN,SUGARBAKER,WARREN+(ROCH)
PUTT      78 PR D17 1466       G.D.PUTT, P.C.M.YOCK                   (AUCK)
SCHIFFER  78 PR D17 2241       +RENNER,GEMMELL,MOORING             CHIC+ANL
YOCK      78 PR D18 641        P.C.M. YOCK                            (AUCK)

BOYD      79 PRL 43 1288       +BLATT,DONOGHUE,DRIES,HAUSMAN,SUITER  (OSU)
BOZZOLI   79 NP B159 363       +BUSSIERE,GIACOMELLI+ (BGNA+LAPP+SACL+CERN)
LARUE     79 PRL 42 142        +FAIRBANK,PHILLIPS                     (STAN)
STEVENSO  79 PR D20 82         M.L.STEVENSCN                           (LBL)

                                  REVIEW ARTICLES

ZAITSEV   72 SJNP 15 656       +LANDSBERG                             (SERP)
JONES     76 RMP 69 717        L.W.JONES                              (MICH)

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MAGNETIC MONOPOLE SEARCHES

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C     MCNOPOLE PROD. CROSS SECTION - ACCELERATOR EXP.     (CM**2)/NUCLEON
C   A   0    1 E-40 OR LESS  CL=.95  AMALDI    63 EMUL    M=0 TO 3 GEV      12/75
C   A   0    5 E-41 OR LESS  CL=.95  AMALDI    63 EMUL    M=0 TO 3.4 GEV    12/75
C   P   0    2 E-40 OR LESS          PURCELL   63 CNTR    M=0 TO 3 GEV      12/75
C   G   0    4 E-43 OR LESS  CL=.95  GUREVICH  72 EMUL    M=0-5 GEV          3/74
C   C   0    6 E-42 OR LESS  CL=.95  CARRIGAN  73 CNTR Q=1/6-24 DIRAC CHAR   3/74
C   M   0    5 E-42 OR LESS  CL=.95  CARRIGAN  74 CNTR    Q=1/30 TO 24      12/75
C   B   0  2.7E-30 OR LESS  CL=.90  BURKE     75 OSPK                        1/78
C   N   0    1 E-39 OR LESS  CL=.95  CARRIGAN  75 HLBC    NEU ENERGY=1.0     1/76
C   N   0    4 E-38 OR LESS  CL=.95  CARRIGAN  75 HLBC    NEU ENERGY=5.0     1/76
C   N   0    1 E-37 OR LESS  CL=.95  CARRIGAN  75 HLBC    NEU ENERGY=8.0     1/76
C   E   0    5 E-44 OR LESS  CL=.95  EBERHARD  75 CNTR    M=0 TO 12 GEV     11/75
C   I   0    2 E-36 OR LESS  CL=.95  GIACOMELL 75 PLAS    M=0 TO 20 GEV      2/76
C   Z   0    1 E-40 OR LESS  CL=.95  ZRELOV    76 CNTR Q=2/3-2 DIRAC CHARG  1/80*
C   R   0  1.3E-37 OR LESS  CL=.95  CARRIGAN  78 CNTR Q=.2-1.2 DIRAC CHGS   2/79*
C   R   0  4. E-37 OR LESS  CL=.95  CARRIGAN  78 CNTR Q=1.2-24 DIRAC CHGS   2/79*
C   H   0 1-10E-37 OR LESS  CL=.95  HOFFMAN   78 PLAS Q=1-3 DIRAC CHGS     2/79*
C   A   AMALDI 63 USES 28 GEV PROT BEAM AT CERN PS. FIRST RESULT IS FOR     12/75
C   A   PROTON TARGET, SECOND IS FOR NUCLEON TARGET INSIDE NUCLEUS.         12/75
C   P   PURCELL 63 LOOKS FOR MONOPOLES PRODUCED BY 30 GEV PROT AT THE AGS.  12/75
C   G   GUREVICH 72 IS A SERPUKHOV 70 GEV/C P EXP. MASS LIMIT FROM PP=PPMM   3/74
C   C   CARRIGAN 73 IS NAL 300 GEV P EXP. MASS LIMIT 0-12 GEV FROM PP=PPMM   3/74
C   M   CARRIGAN 74 IS NAL 400 GEV EXP.  MASS LIMIT 0-13.7 GEV/MONOPOLE.    12/75
C   N   CARRIGAN 75 REEXAMINES OLD CERN NEUTRINO EXPTS IN HLBC. NEU ENERGY   1/76
C   N   GIVEN AT RIGHT REPRESENTS NEUTRINO THRESHOLD ENERGY.                 1/76
C   N   THESE VALUES ARE IN UNITS CM**2/NUCLEUS.                             1/76
C   E   EBERHARD 75 USED NAL TARGETS - 300 GEV AND 400 GEV P ON ALUMINUM.    2/76
C   E   Q=1-7 DIRAC CHGS.  USED SAME TYPE OF DETECTOR AS ROSS 73.            2/76
C   I   GIACOMELLI 75 IS CERN ISR EXP., M=0-30 GEV, Q=0.4-2.5 DIRAC CHGS.    2/76
C   B   BURKE 75 EXPT LOOKS FOR MULTIPHOTON EVENTS FROM ANNIHILATION OF      1/78
C   B   MONOPOLE PAIR. 300 GEV NEUTRON BEAM AT FNAL.                         1/78
C   Z   ZRELOV 76 IS IHEP 70 GEV/C P BEAM EXP. LOOKS FOR CHERENKOV GAMMAS   1/80*
C   Z   WITH CHARACTERISTIC POLARIZATION. LIMIT IS FOR M=3-5.5 PROTON MASS  1/80*
C   Z   AND LIFETIME LARGER THAN OR APPROXIMATELY EQUAL 3*10**-11 SEC.      1/80*
C   R   CARRIGAN 78 IS CERN-ISR EXPT, ECM=23-63 GEV.  LIMIT IS FOR          2/79*
C   R   M <20 GEV.                                                          2/79*
C   H   HOFFMAN 78 IS CERN-ISR EXPT SENSITIVE TO M<30 GEV. SEE THEIR FIG. 2 2/79*
C   H   FOR CS AS A FUNCTION OF MASS AND MAGNETIC CHARGE.                   2/79*
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CS     MONOPOLE PROD. CROSS SECTION - SEARCH IN MATTER      (CM**2)/NUCLEON
CS  G   0   5 E-38 OR LESS          GOTO      63 EMUL   M=1 GEV           12/75
CS  G   0   5 E-36 OR LESS          GOTO      63 EMUL   M=10 GEV          12/75
CS  G   0   5 E-33 OR LESS          GOTO      63 EMUL   M=100 GEV         12/75
CS      0   3 E-40 OR LESS  CL=.95  PETUKHOV  63 CNTR   METEORITE         12/75
CS  C   0   1 E-38 OR LESS  CL=.90  CARITHERS 66 ELEC   M=2 GEV           12/75
CS  C   0   7 E-37 OR LESS  CL=.90  CARITHERS 66 ELEC   M=10 GEV          12/75
CS  C   0   1 E-35 OR LESS  CL=.90  CARITHERS 66 ELEC   M=25 GEV          12/75
CS  F   0   5 E-43 OR LESS  CL=.90  FLEISCH1  69 CNTR   M=1 GEV            2/76
CS  F   0   2 E-40 OR LESS  CL=.90  FLEISCH1  69 CNTR   M=10 GEV           2/76
CS  F   0   3 E-37 OR LESS  CL=.90  FLEISCH1  69 CNTR   M=100 GEV          2/76
CS  F   0   5 E-34 OR LESS  CL=.90  FLEISCH1  69 CNTR   M=1000 GEV         2/76
CS  F   0   1 E-29 OR LESS  CL=.90  FLEISCH1  69 CNTR   M=10000 GEV        2/76
CS  K   0   1 E-42 OR LESS  CL=.95  KOLM      71 CNTR   M=1.5 GEV          3/74
CS  K   0   1 E-42 OR LESS  CL=.95  KOLM      71 CNTR   M=10 GEV           3/74
CS  K   0   1 E-37 OR LESS  CL=.95  KOLM      71 CNTR   M=100 GEV          3/74
CS  K   0   1 E-34 OR LESS  CL=.95  KOLM      71 CNTR   M=1000 GEV         3/74
CS  K   0   1 E-31 OR LESS  CL=.95  KOLM      71 CNTR   M=1500 GEV         3/74
CS  R   0   1 E-43 OR LESS  CL=.95  ROSS      73 ELEC   M=2 GEV            3/74
CS  R   0   5 E-41 OR LESS  CL=.95  ROSS      73 ELEC   M=10 GEV           3/74
CS  R   0   5 E-38 OR LESS  CL=.95  ROSS      73 ELEC   M=100 GEV          3/74
CS  G  GOTO 63 EXAMINES MAGNETITE ROCK IN THE ADIRONDACK MOUNTAINS.       12/75
CS  C  CARITHERS 66 LIMITS ABOVE ARE FOR NUCLEON-NUCLEON INTERACTIONS.    12/75
CS  C  LIMITS FOR PHOTONUCLEON PRODUCTION ARE 10**3 TIMES LARGER.         12/75
CS  F  FLEISCHER 69 LOOKED FOR MONOPOLES IN SEDIMENTS AT BOTTOM OF OCEAN   3/74
CS  F  DEPOSITED DURING THE LAST 16 MILLION YEARS. Q=60 DIRAC CHAR.OR LESS 3/74
CS  K  KOLM 71 TRIED TO DETECT MONOP. IN DEEP SEAWATER Q=.2-27 DIRAC CHAR. 2/76
CS  R  ROSS 73 TRIED TO DETECT MONOP. IN LUNAR DUST    Q=.4-36 DIRAC CHAR  2/76
CS  R  OR LARGER CHARGES EXCEPT FOR G= N*36*GO, WITH N INTEGER.  THEY ALSO 3/74
CS  R  REPORT LIMIT OF DENSITY IN LUNAR MATERIAL AS 1.7*10**-4 MONOP./GM.  2/76

F      MONOPOLE FLUX IN COSMIC RAYS (NUMBER/CM**2-SEC-SR)
F       0   1 E-13 OR LESS          GOTO      63 EMUL    KE TO 10**4 GEV  12/75
F       0   5 E-15 OR LESS  CL=.90  CARITHERS 66 ELEC                     12/75
F   F   0   3 E-19 OR LESS  CL=.90  FLEISCH2  69 SCAN    KE TO 10**10 GEV 12/75
F       0   2 E-18 OR LESS          KOLM      71 CNTR    KE TO 10**5 GEV  12/75
F   R   0   5 E-19 OR LESS  CL=.95  ROSS      73 ELEC    KE TO 10**4 GEV  12/75
F  P    1  (1 E-13)                 PRICE     75 EMUL    M GT 200 GEV     12/75
F   F  FLEISCHER 2 69 LOOKED FOR MONOPOLE TRACKS LEFT IN OBSIDIAN AND MICA 12/75
F   F  OVER GEOLOGICAL TIMES.                                             12/75
F   R  ROSS 73 INCLUDES DATA OF EBERHARD 71 PAPER.                        12/75
F  P   THE PRICE 75 EVENT COULD BE EXPLAINED AS DUE TO A FRAGMENTING HEAVY 11/76
F  P   NUCLEUS.  SEE ALVAREZ 75, FLEISCHER 75, FRIEDLANDER 75,AND ROSS 76. 11/76
F  P   SEE EBERHARD 75 FOR DISCUSSION OF CONFLICT WITH OTHER EXPERIMENTS.  12/75
F  P   NOT CONSIDERED CONVINCING EVIDENCE FOR THE EXISTENCE OF MONOPOLES.  12/75
F  P   HAGSTROM 77 GIVES A REINTERPRETATION AS A HEAVY ANTINUCLEUS.         3/77
F  P   SEE PRICE 78 FOR REASSESSMENT OF THE EVENT                          7/79*

D      MONOPOLE DENSITY IN MATTER     (NUMBER/LITER)
D   S   0  1.6E-4  OR LESS          SCHATTEN  70 ELEC  MOON                4/77
D   C   0  4.4E-5  OR LESS  CL=.95  CARRIGAN  76 CNTR   AIR                1/77
D   C   0  1.8E-3  OR LESS  CL=.95  CARRIGAN  76 CNTR   SEA WATER          1/77
D   S  SCHATTEN 70 EXAMINED SATELITE DATA FOR PERTURBATIONS IN THE LUNAR   4/77
D   S  MAGNETIC WAKE. LIMIT IS FOR THE DIFFERENCE IN NUMBERS OF NORTH AND  4/77
D   S  SOUTH MONOPOLES.                                                    4/77
D   C  CARRIGAN 76 IS SENSITIVE TO MONOPOLES WITH DIRAC CHARGE Q=1/6 TO 24 1/77
D   C  AND MASS AS LARGE AS (7500 GEV)*Q.                                  1/77

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                         REFERENCES FOR MAGNETIC MONOPOLE SEARCHES

AMALDI    63 NC 28 773         +BARONI,MANFREDINI,BRADNER+(ROMA+UCSD+CERN)
GOTO      63 PR 132 387        +KOLM,FORD                    (TOKY+MIT+BRAN)
PETUKHOV  63 NP 49 87          +YAKIMENKO                             (LEBD)
PURCELL   63 PR 129 2326       +COLLINS,FUJII,HORNBOSTEL,TURKOT (HARV+BNL)
CARITHER  66 PR 149 1070       CARITHERS,STEFANSKI,ADAIR              (YALE)

FLEISCH1  69 PR 184 1393       FLEISCHER,HART,JACOBS+       (GESC+UNCS+GSCO)
   ALSO   70 JAP 41 958        FLEISCHER,HART,JACOBS,PRICE,SCHWARTZ+(GESC)
FLEISCH2  69 PR 184 1398       FLEISCHER,PRICE,WOODS                  (GESC)
   ALSO   70 JAP 41 958        FLEISCHER,HART,JACOBS,PRICE,SCHWARTZ+(GESC)
SCHATTEN  70 PR D1 2245        SCHATTEN                               (NASA)
KOLM      71 PR D4 1285        +VILLA,ODIAN                       (MIT+SLAC)

GUREVICH  72 PL 38B 549        +KHAKIMOV,MARTEMIANOV+       (KIAE+NOVO+SERP)
   ALSO   70 PL 31B 394        GUREVICH,KHAKIMOV +          (KIAE+NOVO+SERP)
   ALSO   72 JETP 34 917       BARKOV, GUREVICH,            (KIAE+NOVO+SERP)
CARRIGAN  73 PR D8 3717        +NEZRICK,STRAUSS                       (FNAL)
ROSS      73 PR D8 698         +EBERHARD,ALVAREZ,WATT             (LBL+SLAC)
   ALSO   71 PR D4 3260        EBERHARD,ROSS,ALVAREZ,WATT         (LBL+SLAC)
CARRIGAN  74 PR D10 3867       +NEZRICK,STRAUSS                       (FNAL)

BURKE     75 PL 60B 113        +GUSTAFSON,JCNES,LONGO                 (MICH)
CARRIGAN  75 NP B91 279        +NEZRICK                               (FNAL)
   ALSO   71 PR D3 56          CARRIGAN,NEZRICK                       (FNAL)
EBERHARD  75 PR D11 3099       +ROSS,TAYLOR,ALVAREZ,OBERLACK      (LBL+MPIM)
GIACOMEL  75 NC 28A 21         GIACOMELLI,ROSSI+      (BGNA+CERN+SACL+ROMA)

PRICE     75 PRL 35 487        +SHIRK,OSBORNE,PINSKY           (UCB+HOUSTON)
   ALSO   75 LBL-4260          LUIS ALVAREZ                            (LBL)
   ALSO   75 LBL-4289          PHILIPPE EBERHARD                       (LBL)
   ALSO   75 PRL 35 1412       R.L. FLEISCHER,R.M.WALKER         (GESC+WUSL)
   ALSO   75 PRL 35 1167       M.W. FRIEDLANDER                       (WUSL)
   ALSO   76 LBL-4665          RONALD ROSS                             (LBL)
   ALSO   77 PRL 38 729        RAY HAGSTROM                            (LBL)
   ALSO   78 PR D18 1382       PRICE,SHIRK,OSBORNE,PINSKY(LBL,UCB,HOUSTON)

CARRIGAN  78 PR D13 1823       +NEZRICK,STRAUSS                       (FNAL)
ZRELOV    76 CZJP B26 1306     +KOLLAROVA,KOLLAR,LUPILTSEV,PAVLOVIC+(JINR)

CARRIGAN  78 PR D17 1754       +STRAUSS,GIACOMELLI               (FNAL+BGNA)
HOFFMAN   78 LNC 23 357        +KANTARDJIAN                      (CERN+RCMA)
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CHARM SEARCHES

Data on specific charmed states are listed in separate sections in the appropriate places in the Data Card Listings: D, F, and Λ_c — Stable Particles; D^*, F^* — Mesons; Σ_c — Baryons.

Stable Particles
CHARM SEARCHES

Data Card Listings
For notation, see key at front of Listings.

Evidence for charm not directly relatable to a given state is listed in this section. Neutrino-induced dilepton events are summarized. Short-lived tracks in emulsions are also dealt with, as are cross-section upper limits for charm searches.

Tri-muon production in neutrino interactions is summarized in the Other New Particle Searches section.

Neutrino-induced Dilepton Events

Many neutrino experiments have now observed dilepton events. These data are summarized in subsections Y, V0, and V0A. Bubble chamber experiments have observed neutrino-induced μ^-e^+ events associated with strange particle production in the reaction

$$\nu N \to \mu^- e^+ K^0 (\text{or } \Lambda) + \text{anything} \quad .$$

Dilepton events have no conventional explanation. Production of charmed hadrons, heavy leptons, and intermediate bosons have been proposed as potential explanations. Production of charmed particles (C) in neutrino interactions would be expected to give rise to such events via the mechanism

$$\nu_\mu N \to \mu^- C + \text{hadrons}$$
$$\hookrightarrow \ell^+ \nu_\ell + \text{hadrons} \quad ,$$

where the Cabibbo-favored transition would predict a strange particle among the hadrons. Thus the appearance of neutrino-induced dimuon events, μ^-e^+ events, and associated strange particles can be understood via the charm mechanism.

Short-Lived Tracks in Emulsions

The mean life of a weakly decaying charmed meson or baryon of mass M (in GeV) is expected to be in the range[1]

$$\tau = (10^{-11} \text{ to } 10^{-13} \text{ sec}) \times 1/M^5$$

with a corresponding mean path length for lab momentum p (in GeV/c) of

$$\ell = \frac{pc\tau}{M} = (30\mu \text{ to } 3000\mu) \times p/M^6 \quad .$$

Thus even at Fermilab energies, these would be hard to see as tracks in bubble chambers, so emulsion is used. We list data for these experiments in subsections CC and EM below.

Charm Searches

Experimental evidence for charm production has now been accumulated in various reactions.

Section CP includes several types of evidence for associated charm production in pN collisions: the prompt 1μ signal, low mass $\mu^+\mu^-$ pairs with missing energy; opposite-sign μe events; as well as observations of D and Λ_c in the hadronic final states. Observations of prompt muons in beam dump experiments are listed in section BD.

Sections CG, MU, and D include evidence in photon, muon, and neutrino beam experiments. Charmed baryon production in e^+e^- reactions is listed in section CE; further information can be obtained from the Listings.

References

1. M.K.Gaillard, B.W.Lee, and J.L.Rosner, Rev. Mod. Phys. 47, 277 (1975).


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       PROPERTIES OF THE CHARMED D, D*, F, F*, LAMBDA/C+, AND SIGMA/C+
       STATES ARE LISTED IN SEPARATE SECTIONS.
       THE FOLLOWING SECTICN CONTAINS INFORMATION ON SEARCHES FOR
       OTHER CHARMED PARTICLE STATES AND SEARCHES FOR THE ABOVE STATES
       IN NEW COLLISION PROCESSES.   THESE SEARCH RESULTS ARE USUALLY
       LISTED AS CROSS SECTION UPPER LIMITS.
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CE     CHARMED BARYON PRODUCTION IN (E+ E-) COLLISIONS    (CM**2)
CE   I                               PICCOLO   77 SMAG                   1/78
CE   F     (5.6E-35)OR LESS  CL=.90  FERGUSON  78 SMAG                   2/79*
CE   I  PICCOLO 77 LOOK AT INCLUSIVE PBAR AND LAMBDA PROD IN 3.7-7.6 GEVECM  1/78
CE   I  E+E- AT SLAC. FINDS SHARP RISE IN CS BETW 4.4 AND 5 GEV. EVIDENCE    1/78
CE   I  FOR PROD OF CHARMED BARYON IN THAT REGION.                       1/78
CE   F  FERGUSON 78 FIND INCREASE IN ANTISIGMA +- PROD BY E+ E- (SLAC)   2/79*
CE   F  BETWEEN 4 AND 7 GEV (ECM)  CONSISTENT WITH CHARMED BARYON        2/79*
CE   F  PRODUCTION. LIMIT IS ON C.S.*BR(ALAMBDAC- --> ASIG+- PI-+ PI-).  12/79*

CG     CHARMED HADRON PRODUCTION CROSS SECTIONS (GAMMA NUCLEON)  (CM**2)
CG   K  60 EVENTS                    KNAPP     76 SPEC LAMBCABAR PI-PI-PI+  2/77
CG   Q   0  1.1E-31 OR LESS  CL=.95  QUINN     76 HBC     B++ M-         9/77
CG   Q   0  1.2E-31 OR LESS  CL=.95  QUINN     76 HBC     B+ M0          9/77
CG   A  94  (7.2+-2.9)E-31           ATIYA     79 SPEC D0-->K+- PI-+     12/79*
CG   D   1 EVENT                     ADAMOVICH 80 SPEC    D0BAR-->K+3(PI)-  1/80*
CG   K  KNAPP 76 SEES A PEAK AT M=2.26+-0.01 GEV/C**2. WIDTH IS 40+-20 MEV,  2/77
CG   K  CONSISTENT WITH ZERO WIDTH STATE (RESOLUTION=30 MEV). NO PEAK SEEN   2/77
CG   K  IN LAMBDABAR PI+ PI+ PI-. THEY ALSO SEE A LAMBDABAR (4PI)0 PEAK AT   2/77
CG   K  2.5 GEV CASCADING DOWN TO THE PEAK AT 2.26. EXPT USEC WIDE-BAND      2/77
CG   K  PHOTON BEAM AT FNAL.                                             2/77
CG   Q  QUINN 76 USED A 9.3 GEV PHOTON BEAM AT SLAC. SEE TABLES 1 AND 3 FOR  2/77
CG   Q  INDIVIDUAL CHANNELS. ABOVE LIMITS ARE FOR ALL CHANNELS WITH ONE OR   2/77
CG   Q  NO MISSING NEUTRALS.                                             2/77
CG   A  ATIYA 79 IS FNAL EXPT USING 50-200 GEV PHOTONS. C.S. ASSUMES     12/79*
CG   A  BRANCHING RATIO OF D0-->K+-P-+ =.018.                            12/79*
CG   D  ADAMOVICH 80 SEES THE PRODUCTION AND DECAY OF A D0BAR IN EMULSION  1/80*
CG   D  EXPOSED TO SPS GAMMA BEAM IN CONJUNCTION WITH OMEGA SPECTROMETER.  1/80*

MU     CHARMED HADRON EVIDENCE IN MU NUCLEON INTERACTIONS (CM**2)        12/79*
MU   B     (3. E-33)APPROX           BAUER     79 SPEC   270 GEV MU+ BEAM 12/79*
MU   B  BAUER 79 SEES 449 DIMUONS, 64 TRIMUONS. CONSISTENT WITH ASSOCIATED  12/79*
MU   B  PRODUCTION AND SEMILEPTONIC DECAY OF CHARMED MESONS. SEE ALSO    12/79*
MU   B  LISTINGS UNDER S30MU (CHANG 77).                                 12/79*

CPI    CHARMED HADRON PRODUCTION CROSS SECTION (PI NUCLEON)   (CM**2)
CPI  B   0 1.5 TO 3.7 E-30 OR LESS   BALTAY    75 HBC     15 GEV PI+P    7/76
CPI  B   0 0.2 TO 35  E-30 OR LESS   BALTAY    75 HBC     15 GEV PI+P    7/76
CPI  P      8. E-33 OR LESS  CL=.90  APEL      76 ASPK    40 GEV/C PI-   1/78
CPI  U   0 0.5 TO 15 E-30 OR LESS    BUNNELL   76 STRC    CL=.97         1/77
CPI  C   0  1. TO 8. E-31  OR LESS   CESTER    76 SPEC    15 GEV/C PI-   2/77
CPI  G   0  4. TO 8. E-32  OR LESS   GHIDINI   76 SPEC    19 GEV/C PI P  2/77
CPI  H   0  4. E-30 OR LESS  CL=.95  HAGOPIAN  76 DBC  SHORT LIVED 2-5GEV  2/76
CPI  H   1  7. E-31 OR LESS  CL=.95  HAGOPIAN  76 DBC  LONG LIVED 1.9-2GEV 2/76
CPI  H   0  3. E-31 OR LESS  CL=.95  HAGOPIAN  76 DBC  LONG LIVED1-1.9,2-5 2/76
CPI  K   0  3. E-28 OR LESS          KLEMS     76 HYBR 200 GEV/C PI- DEUT 1/80*
CPI  A   0  3.8E-31 OR LESS  CL=.95  BLANAR    77 SPEC    200 GEV/C PI+  4/77
CPI  S          .028 OR LESS CL=.90  BRANSON   77 SPEC PI+ SEE NOTE S    7/77
CPI  S          .041 OR LESS CL=.90  BRANSON   77 SPEC PI- SEE NOTE S    7/77
CPI  D      2.6E-30 OR LESS  CL=.95  GODDARD   77 HBC  D0BAR C++         1/78
CPI  J   0  5.7E-34 OR LESS          JONCKHEER 77 STRC    225 GEV/C PI-  1/78
CPI  N   0  9. E-30 OR LESS  CL=.90  ANTIPOV   78 SPEC 55 GEV/C PI- BE   1/80*
CPI  N   0  2. E-29 OR LESS  CL=.95  ANTIPOV2  78 SPEC 55 GEV/C PI- BE   1/80*
CPI  L      2.4E-30 OR LESS  CL=.90  BALLAM    78 HBC  18 GEV/C PI+P,PI-P  1/79*
CPI  L      1.3E-29 OR LESS  CL=.90  BALLAM    78 HBC  ASSOC.PROD OF D+D-  1/79*
CPI  E      8.7E-32 OR LESS  CL=.9999 CESTER   78 SPEC 10.5 GEV/C PI- N  1/78
CPI  B  BALTAY 75 SENSITIVE TO CHARMED PARTICLES WITH M=1.5 TO 4.0 GEV AND  7/76
CPI  B  TAU LT 10**-11 WHICH THEN DECAY INTO STRANGE PARTICLES.          7/76
CPI  B  THE FIRST VALUE ABOVE IS FOR ASSOC PROD OF CHARMED PARTICLES.    7/76
CPI  B  SEE THEIR TABLE 1 FOR SPECIFIC DECAY MODES.  THE SECOND RANGE OF  7/76
CPI  B  VALUES IS FOR INCLUSIVE PROD OF CHARMED MESONS AND BARYONS WITH  7/76
CPI  B  CHARGES -2 TO +2. SEE HIS TABLE 2 FOR SPECIFIC DECAY MODES.      7/76
CPI  P  APEL 76 IS SERP EXPT. LOOKS FOR PI- P --> D0 AD0 N, D0 --> K0 PI0.  1/78
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Data Card Listings
For notation, see key at front of Listings.

Stable Particles
CHARM SEARCHES

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CPI  U  BUNNELL 76 IS A SLAC 15.5 GEV PI+P EXPT. ALL POSSIBLE 2 TO 5-BODY    1/77
CPI  U  MASS COMBINATIONS WERE STUDIED FOR NARROW RESONANCES PRODUCED IN     1/77
CPI  U  COINCIDENCE WITH SINGLE MUONS. MASS RANGE STUDIED WAS UP TO 3.1GEV.  1/77
CPI  U  SEE TABLE 1 ON PG 87 FOR DETAILED RESULTS OF INDIVIDUAL CHANNELS.    1/77
CPI  C  CESTER 76 LOOKS AT MASS RANGE 1.8 TO 2.5 GEV. SEE TABLE 1 FOR        2/77
CPI  C  INDIVIDUAL CHANNELS. VALUES GIVEN ARE CROSS-SEC/NUCLEON ON CARBON.   2/77
CPI  G  GHIDINI 76 LOOKED FOR CHARMED MESONS OF MASS GT 1.5 GEV AND BARYONS  2/77
CPI  G  OF MASS GT 2.0 GEV. LIMITS ARE CL=.95. LIMITS FOR MOST CHANNELS LIE  2/77
CPI  G  IN THE ABOVE RANGE. SEE TABLE 2 FOR INDIVIDUAL CHANNELS.             2/77
CPI  H  HAGOPIAN 76 IS A SLAC 15GEV PI+ D EXPT. ALL POSSIBLE TWO AND THREE    2/76
CPI  H  BODY MASS COMBINATIONS WERE STUDIED FOR NARROW RESONANCES WITH MASS  2/76
CPI  H  1.5-5GEV FOR MESONS AND 2-5GEV FOR BARYONS. INDIVIDUAL LIMITS FOR     2/76
CPI  H  TWO AND THREE BODY DECAY FROM MANY REACTIONS ARE GIVEN.              2/76
CPI  H  VEES WERE STUDIED FOR THE POSSIBILITY OF A NEW LONG LIVED (MEAN      2/76
CPI  H  LIFE 1E-11 SEC. OR MORE) NEUTRAL PARTICLE. ONE CANDIDATE WITH MASS   2/76
CPI  H  1.9-2 GEV WAS FOUND. SECOND LONG LIVED LIMIT FOR M=1-1.9, 2-5 GEV.   2/76
CPI  K  KLEMS 76 LOOKS FOR ASSOCIATED PROD OF CHARMED MESON IN SEMILEPTONIC   1/80*
CPI  K  DECAY MODE. SEE THEIR FIG.2 AND 3 FOR C.S. UPPER LIMIT VS MASS.      1/80*
CPI  A  BLANAR 77 IS FNAL EXPT. LIMIT IS FOR CS*BR TO MUONS. ASSUMES         4/77
CPI  A  DIFFRACTIVE CHARMED 2GEV MESON PAIR PRODUCTION. OTHER LIMITS FOR     4/77
CPI  A  PI AND P BEAMS GIVEN IN TABLE 1.                                     4/77
CPI  S  BRANSON 77 MEASURES (PI NUC -->J C CBAR)/(PI NUC -->J ANYTHING)      7/77
CPI  S  WITH J,C, AND CBAR ALL DECAYING TO MUONS. FNAL EXPT. FIRST VALUE      7/77
CPI  S  ABOVE IS FOR 225 GEV/C PI+ BEAM, SECOND IS FOR 225 GEV/C PI- BEAM.   7/77
CPI  D  GOODARD 77 IS A SLAC PI+ P EXPT AT 4.51 GEV ECM.                     1/78
CPI  J  JCNCKHEERE 77 LOOKS FOR CORRELATION BETW VOS AND PROMPT MUONS TO     1/78
CPI  J  SIGNAL DECAY OF CHARMED PARTICLE.                                    1/78
CPI  N  ANTIPOV 78 SEARCHED FOR PI- BE --> DO DOBAR X WHERE DO --> K+ PI-.   1/80*
CPI  N  ANTIPOV2 78 SEARCHED FOR DO C X WHERE DO--> K PI, C IS ANY           1/80*
CPI  N  CHARMED PARTICLE --> MU. BOTH ARE SERPUKHOV EXPTS.                   1/80*
CPI  L  BALLAM 78 IS SLAC EXPT SEARCHING FOR SEMIELECTRONIC DECAY MODE OF    1/79*
CPI  L  ASSOC. PRODUCED CHARMED PARTICLES. FIRST VALUE ABOVE IS FOR C.S.*    1/79*
CPI  L  SUM OF BRANCHING RATIOS INTO ELECTRON ANYTHING. SECOND VALUE USES    1/79*
CPI  L  KNOWN BR FOR D+-->E X TO YIELD CS.                                   1/79*
CPI  E  CESTER 78 IS BNL EXPT, LOOKS FOR PI- N-->D*- X, D*- --> DOBAR PI-,   1/78
CPI  E  DOBAR-->K+ PI-. VALUE CORRESPONDS TO A ROUGH LIMIT OF 2*10**-31      1/78
CPI  E  CM**2 FOR DOBAR PROD AND DECAY TO KPI.                               1/78
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CP      CHARMED HADRON PRODUCTION CROSS SECTION (P NUCLEON)   (CM**2)
CP   A   0  1. E-33 OR LESS               AUBERT     75 SPEC    PI+ K-          2/76
CP   A   0  4. E-33 OR LESS               AUBERT     75 SPEC    K+ PI-          2/76
CP   A   0  1. E-33 OR LESS               AUBERT     75 SPEC    K+ K-           2/76
CP   A   0  8. E-33 OR LESS               AUBERT     75 SPEC    PI+ PI-         2/76
CP   A   0  7. E-33 OR LESS               AUBERT     75 SPEC    P K-            2/76
CP   A   0  2. E-33 OR LESS               AUBERT     75 SPEC    K+ PBAR         2/76
CP   A   0  4. E-32 OR LESS               AUBERT     75 SPEC    P PI-           2/76
CP   A   0  2. E-33 OR LESS               AUBERT     75 SPEC    PI+ PBAR        2/76
CP   H   0  5. TO 20. E-30   OR LESS      AAHLIN     76 HBC     BARYON,M LT 2GEV  2/77
CP   H   0 15. TO 100.E-30   OR LESS      AAHLIN     76 HBC     BARYON,M 2-3 GEV  2/77
CP   H   0 10. TO 35. E-30   OR LESS      AAHLIN     76 HBC     MESON, M 1-2 GEV  2/77
CP   L   0  0.05 TO 1.35E-27 OR LESS      ALBROW     76 SPEC    K PI, K P       1/78
CP   B   0  2. E-30 OR LESS               BINTINGER  76 SPEC    M=2 GEV/C**2    1/77
CP   B   0  5. E-32 OR LESS               BINTINGER  76 SPEC    M=4 GEV/C**2    1/77
CP   C   0  9. E-30 OR LESS  CL=.95       ALDER      77 SPEC    DO --> K- PI+   12/77
CP   C   0  8. E-30 OR LESS  CL=.95       ALDER      77 SPEC    DOBAR--> K+ PI- 12/77
CP   S        .04  OR LESS   CL=.90       BRANSON    77 SPEC    SEE NOTE S BELOW  7/77
CP   D   0  3.6E-31 OR LESS  CL=.95       DITZLER    77 SPEC    DO --> K- PI+   1/78
CP   D   0  2.9E-31 OR LESS  CL=.95       DITZLER    77 SPEC    DOBAR --> K+ PI-  1/78
CP   U   0  7.6E-29 OR LESS  CL=.95       BAUM       78 SPEC PP-->D DBAR ANYTHNG  2/79*
CP   R  32 (7.0+-3.6)E-29                 CLARK      78 SPEC PP-->D DBAR ANYTHNG  2/79*
CP   T   0  1.0E-31 OR LESS               LAUTERBAC  78 SPEC   D+,DO TO K MU NU 12/79*
CP   K      2.6E-29 OR LESS  CL=.95       BRANSON    79        PP-->DODOBAR + D+D- 12/79*
CP   K      5.9E-29 OR LESS  CL=.95       BRANSON    79        PP-->DODOBAR + D+D- 12/79*
CP   W     (1.3 TO 6.0)E-29               BROWN      79 SPEC                    12/79*
CP   V     (1.01+-0.23)E-29               CHILINGAR  79 SPEC D DBAR INCLUSIVE   12/79*
CP   M     (7 TO 20)E-30                  DIAMANTBE  79 CNTR D,DBAR --> MUONS   12/79*
CP   I      6.7E-28 OR LESS  CL=.95       DISHAW     79 CALO 400 GEV PP -->DDBAR 12/79*
CP   E  92(1.5-20)E-28                    DRIJARD    79 SFM      D+ -->K-PI+PI+  12/79*
CP   E     (3.0 TO 6.2)E-30               DRIJARD2   79 SFM   LAM/C+ TO KOBAR* P 12/79*
CP   E     (3.3 TO 6.7)E-30               DRIJARD2   79 SFM   LAM/C+ TO K- DEL++ 12/79*
CP   G     (0.7 TO 1.8)E-30               GIBONI     79 SPEC LAM/C+ -->K- PI+ P 12/79*
CP   G     (0.3 TO 0.7)E-30               GIBONI     79 SPEC LAM/C+-->LAM (3PI)+ 12/79*
CP   N     (2.3+-0.3)E-30                 LOCKMAN    79 SPEC LAM/C+-->K- PI+ P  12/79*
CP   N     (2.8+-1.0)E-30                 LOCKMAN    79 SPEC LAM/C+-->LAM (3PI)+ 12/79*
CP   A  AUBERT 75 IS A BNL 30 GEV EXPT. LOOKS FOR P BE --> JPRIME ANYTHING   2/76
CP   A  WHERE JPRIME DECAYED VIA THE CHANNEL SHOWN. ABOVE VALUES ARE         2/76
CP   A  FOR M=2.25GEV AND ASSUME A WIDTH SMALL COMPARED TO THE RESOLUTION.   2/76
CP   A  UPPER LIMITS ARE ALSO GIVEN FOR THE ABOVE CHANNELS AND P PBAR FOR    2/76
CP   A  M=3.1 AND 3.7 GEV. THOSE LIMITS RANGE FROM 7E-36 TO 4E-33.           2/76
CP   A  MA 77 SAYS AUBERT 75 LIMITS SHOULD BE AN ORDER OF MAG. LARGER.       2/77
CP   H  AAHLIN 76 IS A 19 GEV/C P-P EXPT AT CERN. VALUES GIVEN ARE CL=.975.  2/77
CP   H  SEE TABLE 2B, PG 479 FOR INDIVIDUAL LAMBDA (OR KS) +PIONS CHANNELS.  2/77
CP   L  ALBROW 76 IS ISR EXPT, ECM=53GEV. SEE THEIR TABLE 2B,PG 377 FOR      1/78
CP   L  INDIVIDUAL MESON AND BARYON CHANNELS. EXAMINES MASS RANGE 2-4 GEV.   1/78
CP   B  BINTINGER 76 IS CROSS-SEC TIMES BR INTO K- PI+.  WE SHOW TWO VALUES  1/77
CP   B  FROM THEIR FIG.4 WHICH COVERS MASS RANGE 1.7-4 GEV.  SIMILAR LIMITS  1/77
CP   B  ARE GIVEN FOR K+ PI- AND PI+ PI- CHANNELS.  LIMITS ARE PROPORTIONAL  1/77
CP   B  TO CS*BR FOR J/PSI INTO MU+ MU-, TAKEN=1ONB FOR ABOVE VALUES.        1/77
CP   C  ALDER 77 IS CERN-ISR EXPT AT ECM=53 GEV.                            12/77
CP   S  BRANSON 77 MEASURES (P NUC -->J C CBAR)/(P NUC -->J ANYTHING) WITH   7/77
CP   S  J,C, AND CBAR ALL DECAYING TO MUONS.FNAL EXPT USING 225 GEV/C BEAM.  7/77
CP   D  DITZLER 77 IS FNAL 400GEV P EXPT.  ABOVE LIMITS ARE FOR              1/78
CP   D  BR(K PI)*DSIGMA/DY AT Y(CM)=-0.4.                                    1/78
CP   U  BAUM 78 IS ISR EXPT AT ECM=55 GEV. MEASURES CS*BR(D-->E)*BR(D-->MU)  2/79*
CP   U  <.92 MICROBNS AT THIS ENERGY.                                        2/79*
CP   R  CLARK 78 IS CERN-ISR EXPT LOOKING FOR E+- MU-+ EVENTS. ERROR IS      2/79*
CP   R  STATISTICAL ONLY. ASSUMES THE SEMILEPTONIC BRANCHING FRACTIONS OF    2/79*
CP   R  THE D INTO ELECTRONS AND MUONS AS 10 PERCENT EACH.                   2/79*
CP   T  LAUTERBACH 78 RESULT BASED ON POLARIZATION OF PROMPT MUONS IN 400   12/79*
CP   T  GEV P-NUCLEON INTERACTIONS. IF B.R. OF D-->MU =.07, CS<7 E-31.      12/79*
CP   K  FIRST BRANSON 79 VALUE IS AT ECM=19.4 GEV, SECOND AT ECM=27.4 GEV.  12/79*
CP   W  BROWN 79 SEES PROMPT 1 MUON SIGNAL IN 400 GEV PROTONS ON STEEL.     12/79*
CP   W  UNCERTAINTY IN C.S. IS DUE TO MODEL DEPENDENCE.                     12/79*
CP   V  CHILINGAROV 79 ANALYZE CERN ISR EXPT AT 53 AND 63 GEV ECM FOR LOW   12/79*
CP   V  MASS LEPTON PAIR PRODUCTION. VALUE ABOVE IS C.S. PER UNIT OF        12/79*
CP   V  RAPIDITY NEAR Y=0.                                                  12/79*
CP   M  DIAMANTBERGER 79 USES 400 GEV PROTONS ON FE AND LOOKS FOR MISSING   12/79*
CP   M  ENERGY IN MU+MU- PRODUCTION INDICATIVE OF FINAL STATE NEUTRINOS.    12/79*
CP   I  DISHAW 79 IS A CALORIMETRIC EXPT AND LOOKS FOR LOW ENERGY TAIL OF   12/79*
CP   I  ENERGY DISTRIBUTUIONS DUE TO ENERGY LOST TO WEAKLY INTERACTING      12/79*
CP   I  PARTICLES. ASSUMES SEMILEPTONIC B.R.=0.11.                          12/79*
CP   E  DRIJARD 79 IS CERN-ISR EXPERIMENT AT ECM=53 GEV.  FOUND A PEAK AT   12/79*
CP   E  DMASS IN K- PI+ PI+ MASS DISTRIBUTION WHEN MASS OF AT LEAST ONE OF  12/79*
CP   E  TWO (K-PI+) PAIRS IS REQUIRED INSIDE THE K*(890) REGION. CORRECTED  12/79*
CP   E  FOR BRANCHING RATIO. SEE TABLE 3 FOR C.S. ESTIMATION.               12/79*
CP   E  DRIJARD2 79 IS CERN ISR EXPT AT 53 GEV ECM. SEES MASS ENHANCEMENT   12/79*
CP   E  AT 2.26 GEV IN BOTH CHANNELS. RANGE IN VALUES DUE TO MODEL          12/79*
CP   E  DEPENDENCE. VALUES ARE SIGMA*BR FOR MODES SHOWN.                    12/79*
CP   G  GIBONI 79 IS CERN ISR EXPT AT 63 GEV ECM.SEES MASS ENHANCEMENT NEAR 12/79*
CP   G  2.255 GEV IN BOTH CHANNELS. VALUES ARE SIGMA*BR FOR MODES SHOWN.    12/79*
CP   N  LOCKMAN 79 IS A CERN ISR EXPT AT 53 AND 62 GEV ECM. SEES A MASS     12/79*
CP   N  ENHANCEMENT AT 2.29 GEV IN BOTH CHANNELS. VALUES ARE SIGMA*BR FOR   12/79*
CP   N  MODES SHOWN AND FOR 0.75<X<0.90 IN ONE HEMISPHERE.                  12/79*
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CN      CHARMED HADRON PRODUCTION CROSS SECTION (N NUCLEON)   (CM**2)
CN   B   0  1.9E-31 OR LESS               BLESER     75 SPEC K+PI-, M=1.8 GEV     2/77
CN   B   0  1.0E-31 OR LESS               BLESER     75 SPEC K+PI-, M=2.5 GEV     2/77
CN   B   0  1.0E-31 OR LESS               BLESER     75 SPEC K- P , M=2.5 GEV     2/77
CN   W   0  2.5E-29 OR LESS  CL=.975      WARD       75 HBC     KS PI+ PI-        1/77
CN   A   0  6. E-32 OR LESS               ABOLINS    76 SPEC    PI+ PI-           1/77
CN   A   0  7. E-32 OR LESS               ABOLINS    76 SPEC    PBAR P            1/77
CN   A   0  4. E-32 OR LESS               ABOLINS    76 SPEC    K- PI+            1/77
CN   A   0  6. E-32 OR LESS               ABOLINS    76 SPEC    K- P              1/77
CN   G 0-2 SEE COMMENT G BELOW            BINKLEY    76 SPEC                      1/77
CN   L   0 1.-10.E-31 OR LESS             ABOLINS    78 SPEC                      6/78*
CN   T   0  2. E-31 OR LESS  CL=.90       BBDMPST    78 SPEC    C+ TO LAMBDA PI+  7/79*
CN   T   0  2.5E-31 OR LESS  CL=.90       BBDMPST    78 SPEC    D+- TO KO PI+-    7/79*
CN   P   0  3.4E-31 OR LESS  CL=.95       LIPTON     78 SPEC                      8/78*
CN   S   0  2.0E-31 OR LESS  CL=.95       SPELBRING  78 SPEC K+- PI-+, M=1.86GEV  8/78*
CN   D   0  3.8E-31 OR LESS  CL=.90       BBDMPSST   79 SPEC DO --> K- PI+       12/79*
CN   D   0  3.2E-31 OR LESS  CL=.90       BBDMPSST   79 SPEC DOBAR --> K+ PI-    12/79*
CN   D   0  1.3E-30 OR LESS  CL=.90       BBDMPSST   79 SPEC D+ --> K- PI+ PI+   12/79*
CN   D   0  1.1E-30 OR LESS  CL=.90       BBDMPSST   79 SPEC D- --> K+ PI- PI-   12/79*
CN   D   0  5.9E-31 OR LESS  CL=.90       BBDMPSST   79 SPEC F+ --> K+ K- PI+    12/79*
CN   D   0  4.8E-31 OR LESS  CL=.90       BBDMPSST   79 SPEC F- --> K+ K- PI-    12/79*
CN   D   0  1.3E-30 OR LESS  CL=.90       BBDMPSST   79 SPEC LAM/C+ -->P K- PI+  12/79*
CN   D   0  2.3E-31 OR LESS  CL=.90       BBDMPSST   79 SPEC LAM/C+ -->P KOBAR   12/79*
CN   B  BLESER 75 USES NEUTRONS UP TO 300 GEV/C, BE TARGET. EXAMINES MASS    2/77
CN   B  RANGE UP TO 3.5 FOR KPI, UP TO 4.0 FOR KP. VALUES ARE CROSS-SEC/NUC  2/77
CN   W  WARD 75 IS N-P EXPT WITH MOM UP TO 24 GEV/C. THIS VALUE IS FOR MASS  1/77
CN   W  RANGE 1.5-2.5 GEV.  SEE TABLE 1 PG 31 FOR UPPER LIMITS ON C++,C+,    1/77
CN   W  CO,D+,DO,D- DECAYS INTO VARIOUS FINALSTATES IN MASS RANGE 1.5-5GEV.  1/77
CN   W  UPPER LIMIT FOR SEEING DECAY OF CHGD CHARMED PARTICLE INTO VO FOR    1/77
CN   W  TAU GT 10**-11 SEC GIVEN AS 1.5*EXP(T) FOR VO =LAMBDA OR SIGMA, AND  1/77
CN   W  3.0*EXP(T) FOR VO=KO. HERE, T=10*-11/TAU, CS GIVEN IN MICROBARNS.    1/77
CN   A  ABOLINS 76 IS FNAL EXPT. USES NEUTRONS UP TO 300 GEV/C ON BE TARG.   1/77
CN   A  TYPICAL VALUES ABOVE ARE FOR M=3.0 GEV. SEE FIG 4 FOR MASS RANGE     1/77
CN   A  2-4 GEV. OBSERVES POSSIBLE K- PI+ ENHANCEMENT AT 2.29+-.03 GEV.      1/77
CN   G  BINKLEY 76 MEASURES BR(C TO MU + OTHERS)*R WHERE R IS THE RATIO OF   1/77
CN   G  THE CROSS-SEC FOR PRODUCING THE J/PSI TOGETHER WITH A C-CBAR PAIR    1/77
CN   G  TO THE TOTAL CROSS-SEC FOR PRODUCING THE J/PSI AT THIS ENERGY. THE   1/77
CN   G  EXPT WAS A 300 GEV/C FNAL RUN, AND SAW 2 TRI-MUON EVENTS. THIS GAVE  1/77
CN   G  A .90 CL UPPER LIMIT OF .003 FOR THE MEASURED QUANTITY DESCRIBED     1/77
CN   G  ABOVE.                                                               1/77
CN   L  ABOLINS 78 IS A 250 GEV/C N-BE EXPT LOOKING FOR NARROW ENHANCEMENTS  6/78*
CN   L  IN RANGE 1.7-3.5 GEV. CHANNELS EXAMINED ARE PI+PI-, K+-PI-+, K P,    6/78*
CN   L  PBAR P. POSSIBLE K-PI+ PEAK AT 2.29 SEEN IN ABOLINS 76 NOT SEEN      6/78*
CN   L  HERE.  STATISTICS HERE ARE 5 TIMES ABOLINS 76 STATISTICS.            6/78*
CN   L  IF SAME PSI PRODUCTION MODEL WERE ASSUMED HERE AS WAS USED IN        6/78*
CN   L  ABOLINS 76, THE 78 LIMITS WOULD BE SMALLER BY A FACTOR OF 3.         6/78*
CN   T  BBDMPST 78 IS A SERP EXPT USING 45 GEV NEUTRONS.(UNITS CS/NUCLEON).
CN   P  LIPTON 78 IS 300 GEV N-BE EXPT AT FNAL. VALUE QUOTED IS CS/NUC FOR   8/78*
CN   P  ASSOC CHARM PROD WITH ONE CHARMED PARTICLE --> ELECTRON AND THE      8/78*
CN   P  OTHER --> MUON.                                                      8/78*
CN   S  SPELBRING 78 IS 300 GEV N-BE EXPT AT FNAL. VALUE QUOTED IS CS/NUC    8/78*
CN   S  FOR PROD OF DO AND ANOTHER CHARMED PARTICLE WITH DO --> K PI AND     8/78*
CN   S  SECOND CHARMED PARTICLE DECAYING TO PROMPT MUON.                     8/78*
CN   D  BBDMPSST 79 IS SAME EXPERIMENT AS BBDMSST 78.                       12/79*
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CAP     CHARMED HADRON PRODUCTION CROSS SECTION (PBAR NUCLEON)   (CM**2)
CAP  C   0  5. E-29 OR LESS  CL=.95       CARLSSON   75 HBC     PBAR P ANYTHING   2/77
CAP  C   0  3. E-29 OR LESS  CL=.95       CARLSSON   75 HBC     PBAR P PI+ PI-    2/77
CAP  E   0  .8 TO 4.4 E-30   OR LESS      CESTER     76 SPEC    12.4 TO 15 GEV/C  2/77
CAP  J   0  .15 TO 1. E-29   OR LESS      JACHOLKOW  78 BEBC    12GEV/C PBAR P    7/79*
CAP  C  CARLSSON 75 IS A 9GEV PBAR P CERN EXPT.  LIMITS ARE FOR P PBAR PEAK  2/77
CAP  C  IN CHANNELS INDICATED. K KBAR CHANNELS CHECKED BUT NO LIMITS GIVEN.  2/77
CAP  E  CESTER 76 LOOKS AT MASS RANGE 1.8 TO 2.5 GEV. SEE TABLE 1 FOR        2/77
CAP  E  INDIVIDUAL CHANNELS. VALUES GIVEN ARE CROSS-SEC/NUCLEON ON CARBON.   2/77
CAP  J  JACHOLKOWSKA 78 IS CERN EXPT LOOKING FOR NARROW PEAKS IN KO+PIONS    7/79*
CAP  J  AND LAMBDA+PIONS SPECTRA. SEE TABLES 1 AND 2 FOR INDIVID CHANNELS.   7/79*
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BD      BEAM DUMP EXPTS SEARCHING FOR NEUTRAL PENETRATING PARTICLES AND      6/78*
BD      PROMPT NEUTRINOS FROM UNKNOWN SOURCES                                6/78*
BD   A                                    ALIBRAN    78 HYBR    400 GEV PROTONS   6/78*
BD   A  ALIBRAN 78 IS CERN SPS EXPT. SEE EXCESS PROD OF PROMPT ENEU AND      6/78*
BD   A  ENEUBAR EVENTS. COULD BE EXPLAINED BY (CHARMED D PRODUCTION C.S.)    6/78*
BD   A  *BR(D-->E+ NEU X)=32+15/-10 MICROBARNS.                              6/78*
BD   S                                    ASRATYAN   78 CALO                      1/80*
BD   S  ASRATYAN 78 ESTIMATE (D DBAR PROD. C.S.)*BR(D-->E X) AS (1.9+-1.5)   1/80*
BD   S  OR (0.5+-0.4) MICROBARN FOR A**1.5 OR A**1 RESPECTIVELY.             1/80*
BD   B                                    BOSETTI2   78 HYBR    400 GEV PROTONS   6/78*
BD   B  BOSETTI2 78 IS CERN SPS EXPT. OBSERVES PROMPT NEUTRINOS, WITH EQUAL  6/78*
BD   B  FLUXES OF NEU AND NEUBAR OF BOTH E AND MU TYPES. COULD COME FROM     6/78*
BD   B  DECAY OF SHORT-LIVED LIGHT PARTICLES OF NEW TYPE. TAU LEPTONS AND    6/78*
BD   B  AXIONS EXCLUDED. CHARM (D DBAR) PRODUCTION WOULD HAVE TO HAVE        6/78*
BD   B  100-400 MICROBARN CROSS SECTION TO EXPLAIN RESULTS.                  6/78*
BD   H                                    HANSL      78 WIRE    400 GEV PROTONS   6/78*
BD   H  HANSL 78 IS CERN SPS EXPT. SEES PROMPT NEUTRINO FLUX CONSISTENT      6/78*
BD   H  WITH EQUAL AMOUNTS OF ENEU,ENEUBAR,MUNEU,MUNEUBAR. COULD BE          6/78*
BD   H  EXPLAINED AS CHARM(D DBAR) PRODUCTION WITH ABOUT 30 MICROBARN        6/78*
BD   H  CROSS SECTION.                                                       6/78*
BD   C                                    COTEUS     79 OSPK                      7/79*
BD   C  COTEUS 79 IS BNL EXPT. SEES NO EXCESS N.C. RATE IN BEAM DUMP. SETS   7/79*
BD   C  LIMIT FOR CS(PROD)*CS(INT) OF PENETRATING PARTICLES < 5E-68 CM**4    7/79*
BD   C  (CL=.90).                                                            7/79*
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Y       CHARMED HADRON EVIDENCE IN NEUTRINO NUCLEON --> 2 LEPTONS ANYTHING
Y        SEE ALSO SECTION 'NEU' IN 'HEAVY LEPTON SEARCHES' AND
Y        SECTION 'T' IN 'OTHER NEW PARTICLE SEARCHES' AND VO AND VOA BELOW.
Y    B  14MU+MU-   0MU-MU-   0MU+MU+      BENVENU1   75 SPEC    PREDOM. NEU BEAM  2/76
Y    B  51MU+MU-   7MU-MU-   3MU+MU+      BENVENU3   75 SPEC    6/7 NEU BEAM      2/76
Y    B   5MU+MU-   0MU-MU-   2MU+MU+      BENVENU5   75 SPEC    9/10ANTINEU BEAM  2/76
Y        4MU+MU-   4 OTHER MU PAIRS       BARISH     76 SPEC    NEU BEAM          7/76
Y    S   32 DIMUON EVENTS                 ASRATYAN   77 SPEC    NEU BEAM          1/78
Y    A  4MU+E-   6MU-E+                   BALLAGH    77 HLBC .55 NEUBAR,.45 NEU  12/77
Y    L  81 EVENTS MU-E+                   BALTAY     77 HLBC    PREDOM. NEU BEAM  8/77
Y    K   1 EVENT   MU-E+                  BARISH     77 DBC     NEU BEAM          3/77
Y    R  67 MU MU                          BARISH2    77 SPEC FNAL 45-205GEV NEU   1/78
Y    R  28 MU MU                          BARISH2    77 SPEC FNAL 45-205 ANTINEU  1/78
Y    Z                                    BLETZACKE  77 RVUE                      1/78
Y    O  17 EVENTS MU-E+                   BOSETTI    77 HYBR                      7/77
Y    D  11 MU-E+                          DEDEN      77 HLBC                     12/77
Y    H  15 MU-E+                          HAIDT      77 HLBC                      1/78
Y    I 257MU+MU-                          HOLDER     77 SPEC    INCIDENT NEU     12/77
Y    I  58MU+MU-                          HOLDER     77 SPEC    INCIDENT ANEU    12/77
Y    J  47 MU-MU-                         HOLDER2    77 SPEC    NEU BEAM         12/77
Y    J   9 MU+MU+                         HOLDER2    77 SPEC    NEUBAR BEAM      12/77
Y    C  46 MU-MU-   199 MU+ MU-           BENVENUTI  78 SPEC PREDOM. NEU BEAM     1/79*
Y    C   2 MU+MU+    49 MU+ MU-           BENVENUTI  78 SPEC PREDOM. NEUBAR BEAM  1/79*
Y    E  10MU-MU+   3MU-MU-   5MU-E+       BOSETTI1   78 HYBR    NEU BEAM          6/78*
Y    E   2MU+MU-   1MU+E-                 BOSETTI1   78 HYBR    NEUBAR BEAM       6/78*
Y    E  15 MU- E+                         ERRIQUEZ   78 BEBC    NEU BEAM          1/79*
Y    M 94 MU+MU-                          ARMENISE   79 HYBR    NEU BEAM          1/80*
Y    X  12 MU+E-                          BERGE      79 HLBC    NEUBAR BEAM       7/79*
Y    G  67 MU-MU-                         DEGROOT    79 SPEC    NEU BEAM          1/80*
Y    G  19 MU+MU+                         DEGROOT    79 SPEC    NEUBAR BEAM       1/80*
Y    N  34 MU+MU- 35 MU E                 BALLAGH    80 HYBR    NEU BEAM          2/80*
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Stable Particles
CHARM SEARCHES

Data Card Listings
For notation, see key at front of Listings.

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Y    B   BENVENUTI 75 ARE FNAL NEUTRINO NUCLEON EXPERIMENTS WHICH LOOKED FOR  2/76
Y    B   TWO OR MORE MUONS IN THE FINAL STATE.  NO TRIMUON EVENTS WERE SEEN.  2/76
Y    B   AUTHORS STATE THAT THESE DIMUON EVENTS REQUIRE THE EXISTENCE OF ONE  2/76
Y    B   OR MORE NEW PARTICLES WITH M=2-4GEV AND TAU=10**-10SEC. OR LESS.     2/76
Y    B   BENVENUTI4 75 SHOW THAT THE OBSERVED PROPERTIES OF THESE EVENTS      2/76
Y    B   DO NOT AGREE WITH HYPOTHESES OF HEAVY LEPTON OR INTERMEDIATE VECTOR  2/76
Y    B   BOSON.  THEY SUGGEST A HADRON (Y) WITH A NEW QUANTUM NUMBER.         2/76
Y    S   ASRATYAN 77 IS SERPUKHOV EXPT. FINDS R=(DIMUONS/SINGLE MUON EVENTS)  1/78
Y    S   GT (6.2+-1.7)E-3 FOR NEU BEAM AND LT .011 FOR NEUBAR BEAM.           1/78
Y    A   BALLAGH 77 IS AN FNAL EXPT. MEASURES (NEUMU N-->MU- E+ X)/(ALL NUMU 12/77
Y    A   C.C.)=(.34+.23-.13)*10**-2 AND (NEUMUBAR N-->MU+ E- X)/(ALL NUMUBAR 12/77
Y    A   C.C.)=(.15+.14-.08)*10**-2. RATIO OF ANTINEU TO NEU FRACTIONS IS    12/77
Y    A   (0.45+0.6-0.3).
Y    L   BALTAY 77 IS FNAL EXPT IN NEON-H2 MIXTURE.                           8/77
Y    K   BARISH 77 EVENT COULD BE NEU P TO MU+ B++. SEE CHARMED BARYON NOTE   3/77
Y    K   AND LAMBDA/C+ SECTION ABOVE.                                         3/77
Y    R   BARISH2 77 FINDS DIMUON TO SINGLE MUON RATE CONSISTENT WITH CHARM.   1/78
Y    Z   BLETZACKER 77 EXPLAINS TRIMUON AND LIKE SIGN DIMUON PROD AS ASSOC   12/77
Y    Z   PROD OF CHARM.                                                      12/77
Y    C   BOSETTI 77 IS FNAL 15-FT CHAMBER EXPT.                               7/77
Y    D   DEDEN 77 IS CERN WIDE BAND EXPT, EMAX=2 GEV.11+-5 EVENTS ABOVE A    12/77
Y    D   BACKGROUND OF 6 EVENTS.                                             12/77
Y    H   HAIDT 77 IS SAME EXPT AS VONKROGH 76 LISTED UNDER S29VO. MEASURES    1/78
Y    H   (NEUMU N-->MU-E+X)/(NEUMU N-->MU-X)=(.63+-.21)E-2 FOR T(E+)>.8 GEV.  1/78
Y    H   THESE EVENTS HAVE AN AVERAGE OF 2.0+-0.6 KO PER EVENT.               1/78
Y    I   HOLDER 77 IS CERN NARROW-BAND BEAM EXPT IN WHICH ALL MOMENTA ARE    12/77
Y    I   MEASURED.ENERGY SPECTRA,ANG.CORRELATIONS,PT DISTRIBUTIONS ALL IN    12/77
Y    I   AGREEMENT WITH PROD AND DECAY OF CHARMED PARTICLE.                  12/77
Y    J   HOLDER2 77 IS 200GEV NARROW BAND EXPT. AFTER BACKGROUND SUBTRACTION 12/77
Y    J   THE RATE OF LIKE-SIGN DIMUON EVENTS TO CHARGED CURRENT EVENTS IS    12/77
Y    J   (3+-2)*10**-4. MAY COME FROM ASSOC PROD OF CHARM-ANTICHARM PAIR.    12/77
Y    C   BENVENUTI 78 IS FNAL EXPT. MEASURE PROMPT DIMUON RATIO               1/79*
Y    C   (MU-MU)7/(MU-MU+)=.06+-.05 FOR P(MU)>5 GEV/C AND =.12+-.05 FOR       1/79*
Y    C   P(MU)>10 GEV/C. (MU-MU-) MAY COME FROM ASSOCIATED CHARM PRODUCTION.  1/79*
Y    C   ABOVE 80 GEV, THE RATIO OF DIMUON TO SINGLE-MUON EVENTS IS           1/79*
Y    C   (0.65+-0.13)*10**-2 FOR NEU AND (0.70+-0.25)*10**-2 FOR NEUBAR,      1/79*
Y    C   FOR PMU > 5 GEV/C.                                                   1/79*
Y    E   BOSETTI1 78 IS A CERN NE-HBC EXPT USING 200 GEV NARROW BAND BEAM.    6/78*
Y    E   RATE FOR (MU-E+ + MU-MU+)/MU- IN NEU BEAM IS 0.013+-0.004.           6/78*
Y    E   RATE FOR (MU+E- + MU+MU-)/MU+ IN NEUBAR BEAM IS 0.012+-0.005.        6/78*
Y    E   ERRIQUEZ 78 IS CERN SPS EXPT. FINDS (NUMU N-->MU- E+ X)/(ALL NUMU    1/79*
Y    E   C.C.)=(.41+-.15)*10**-2 (TE+>.3GEV). DIRECT E+ PROD. VIA N.C. IS     1/79*
Y    E   <0.2 TIMES C.C.  LIFETIME OF POSSILE E+ PARENT PARTICLE IS LESS      1/79*
Y    E   THAN 3*10**-12 SEC.                                                  1/79*
Y    M   ARMENISE 79 IS A CERN SPS EXPT. FINDS R=(MU+MU-)/(SINGLE MU- EVTS)   1/80*
Y    M   =(0.72+-0.14)E-2. UPPER LIMIT FOR D LIFETIME IS 0.8 E-12SEC(CL=0.9)  1/80*
Y    X   BERGE 79 IS FNAL EXPT IN 15FT CHAMBER USING H-NE MIXTURE. RATE FOR   7/79*
Y    X   (MU+E- X)/(MU+ X)=0.36+-0.11.                                        7/79*
Y    G   DEGROOT 79 IS CERN WIDE BAND EXPT. RATES ARE (MU-MU-)/(1MU-)=        1/80*
Y    G   (3.4+-1.8)E-5, (MU-MU-)/(MU-MU+)=(.041+-.022), (MU+MU+)/(1MU+)=      1/80*
Y    G   (4.3+-2.3)E-5, (MU+MU+)/(MU-MU+)=(.042+-.023).                       1/80*
Y    N   BALLAGH 80 EVENTS INCLUDE DIRECT OBSERVATION OF PROD. AND VISIBLE    1/80*
Y    N   SEMI-LEPTONIC DECAY OF SHORT-LIVED PARTICLES (1 CHGD, 2 NEUTRAL,     1/80*
Y    N   AND 1 UNDETERMINDED CHARGE).                                         1/80*

VO       NUMBER OF VOS PER EVENT IN NEUTRINO NUCLEON--> MU- E+ VO ANYTHING   11/79*
VO       WHERE THE VO IS A KOS OR A LAMBDA (SEE ALSO SECTION Y AND VOA)      11/79*
VO   B   1                              DEDEN      75 HLBC                    2/76
VO   B   1                              BLIETSCHA  76 HLBC                    2/76
VO   V   4                              VONKROGH   76 HLBC                    2/76
VO       15     0.6       0.2           BALTAY     77 HLBC                   11/79*
VO       11     1.84      0.63     0.53 BOSETTI    77 HYBR   KOS/(MU-E+)EVENT 11/79*
VO   D   3                              DEDEN      77 HLBC                   12/77
VO       8      1.7       0.7           BOSETTI1   78 HYBR   KOS/(MU-L+)EVENT 11/79*
VO       5      1.2       0.5           ERRIQUEZ   78 BEBC                    1/79*
VO   A   9      0.53      0.25     0.20 ARMENISE   79 HYBR   KO/(MU+MU-)EVENT 1/80*
VO   A   3      0.03      0.06     0.04 ARMENISE   79 HYBR   LAMDA/(MU+MU-)EV 1/80*
VO   S   1                              BARANOV    79 HLBC                    7/79*
VO   B   THE DEDEN 75 AND BLIETSCHAU 76 EVENTS ARE FROM CERN                  2/76
VO   B   GARGAMELLE NEUTRINO EXPOSURES.  THE MASSES OF THE E+ VO SYSTEM FOR   2/76
VO   B   THE TWO EVENTS ARE 1.24, 1.91 GEV FOR LAMBDA OR 0.65, 1.57 FOR KO.   2/76
VO   V   THE VON KROGH 76 EVENTS ARE FROM AN FNAL 15 FT NEON BUBBLE CHAMBER   2/76
VO   V   EXPOSURE.  ALL FOUR E+ EVENTS FOUND HAVE ASSOCIATED KOS.             2/76
VO   D   DEDEN 77 EVENTS INCLUDE THOSE OF DEDEN 75 AND BLEITSCHAU 76.        12/77
VO   A   ARMENISE 79 IS A CERN SPS EXPT.                                      1/80*
VO   S   BARANOV 79 EVENT FROM SKAT(SERPUKHOV). MAY BE LAMBDA/C+ TO E+NEU     7/79*
VO   S   LAMBDA.                                                              7/79*
VO           . . . . . . . . .
VO  AVG         0.11      0.12      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.5)
VO  STUDENT     0.097     0.066     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

VOA      NUMBER OF VOS PER EVENT IN ANTINEUTRINO NUCLEON-->MU+E-VO ANYTHING  12/79*
VOA      WHERE VO IS A KOS,LAMBDA OR LAMBDABAR(SEE ALSO SECTION Y AND VO)    12/79*
VOA  E   0                              BERGE      77 HLBC                    3/77
VOA  B   8      1.8       0.7           BERGE      79 HLBC                   12/79*
VOA  E   BERGE 77 USED FNAL 15 FT CHAMBER FILLED WITH H-NEON. SAW TWO         3/77
VOA  E   POSSIBLE MU E EVENTS, COMMENSURATE WITH PREDICTED BACKGROUND,        3/77
VOA  E   NEITHER WITH ASSOCIATED VO.                                          3/77
VOA  B   BERGE79 QUOTES 21+-8 NEUTRAL STRANGE PARTICLES FOR 12(MU+E-). WE    12/79*
VOA  B   DIVIDE.                                                             12/79*

R1       CHARMED HADRON BRANCHING RATIO INTO (MU NEU ANYTHING)/TOTAL
R1   B   8     A FEW PERCENT            BENVENU2   75 SPEC    FNAL NEUTRINO NU  2/76
R1   H 315 APPROX 0.15                  HOLDER     77 SPEC                   12/77
R1   A         0.19  OR LESS            BAUM       77                        12/77
R1   D   3      .15        .18      .07 DEDEN      77 HLBC                    1/78
R1   B   BENVENUTI2 75 LOOKS AT ANTINEUTRINO NUCLEON --> MUON HADRONS.  SEES  2/76
R1   B   EXCESS EVENTS ABOVE INCIDENT ENERGY 30 GEV.  COMPARES BENVENUTI1 75  2/76
R1   B   DIMUON EVENTS WITH EXCESS EVENTS TO GET BRANCHING RATIO.             2/76
R1   H   HOLDER 77 VALUE IS FROM NEU AND ANEU INDUCED DIMUON EVENTS OF       12/77
R1   H   OPPOSITE SIGN. SEE SEC. Y LISTING ABOVE. BR CALCULATED USING EFF    12/77
R1   H   BASED ON DECAY OF D+(1850) TO KO MU+ NEU.                           12/77
R1   A   BAUM 77 PUTS UPPER LIMIT ON E+- MU-+ PROD AT ISR. INFERS BR ABOVE   12/77
R1   A   FROM THIS, ASSUMING THAT ALL DIRECT ELECTRONS COME FROM THE D.      12/77
R1   D   DEDEN 77 IS FOR CHARMED BARYON --> LAMBDA LEPTON+ NEU ANYTHING.      1/78
R1   D   SEES 3 NEU N --> MU- E+ VO X EVENTS AND EXCESS OF 42+-20 NEU N -->   1/78
R1   D   MU- LAMBDA X EVENTS OVER EXPECTED ASSOC. PROD.. SUGGESTS CHRM.BAR.   1/78

R2       CHARMED HADRON (ASSOC. VO) BRANCHING RATIO INTO SEMILEPTONICS/ALL
R2   B   2     0.1    OR MORE           BLIETSCHA  76 HLBC     M=2.5-4 GEV    2/76
R2   B   THIS BR.RATIO AND MASS ARE REQD. BY OBSERVED RATE AND CHARM SCHEME.  2/76

R3       CHARMED HADRON BRANCHING RATIO INTO (E NEU ANYTHING)                12/77
R3   B          0.11      0.03          BRANDEL2   77 SPEC E+E- 4-5.2 GEV(ECM) 12/77
R3   B          0.16      0.06          BRANDEL2   77 SPEC E+E- 4-5.2 GEV(ECM) 12/77
R3              0.082     0.019         FELLER     78 SMAG E+E- 3.9-7.4GEV ECM 11/79*
R3   B   FIRST BRANDELIK 77 VALUE USES INCLUSIVE ELECTRON EVENTS. SECOND     12/77
R3   B   VALUE(ERROR STAT ONLY) USES EVENTS WITH A SECOND ELECTRON.          12/77

CC       CHARMED HADRON EVIDENCE IN COSMIC RAYS
CC   N     1 EVENT                      NIU        71 EMUL                    9/76
CC   N   NIU 71 DETECTS CHGD PARTICLE DECAYING INTO HADRON+PIO. MASS=1.78GEV  9/76
CC   N   AND TAU=2.2 E-14 IF SECONDARY IS PION. MASS=2.95 GEV AND TAU=3.6     9/76
CC   N   E-14 IF IT IS PROTON. POSSIBLE EVIDENCE OF PAIR PRODUCTION.          9/76
CC   T     8 EVENTS                     TASAKA     73 EMUL                    9/76
CC   T   SAME TYPE AS NIU EVENT. TAU BETW 1.5 AND 175 E-13.                   9/76
CC   S     1 EVENT                      SUGIMOTO   75 EMUL                    1/77
CC   S   SAME TYPE AS NIU EVENT. TWO SUCH PARTICLES PRODUCED TOGETHER.        1/77
CC   S   TAU1=6.E-13, DECAYS TO CHARGED PRONG + ETA. TAU2=4.E-12, DECAYS TO   1/77
CC   S   CHARGED PRONG + PIO. MASSES OF BOTH PARTICLES ARE ABOUT 2.0 GEV IF   1/77
CC   S   DECAY PRONG IS PROTON, 1.7 IF DECAY PRONG IS KAON, AND 1.55 IF       1/77
CC   S   DECAY PRONG IS PI. COMBINED MASS OT THE TWO NEW PARTICLES = 4.1 GEV  1/77
CC   S   OR 3.8 GEV ASSUMING THE DECAY PRONGS TO BE KAONS OR PIONS            1/77
CC   S   RESPECTIVELY. CONSISTENT WITH LAMBDA/C+ LAMBDABAR/C-.SEE GAISSER 76  1/77
CC   A     4 EVENTS                     SAWAYANAG  79 EMUL                    1/80*
CC   A   SAWAYANAGI 79 ANALYZE BRAZIL-JAPAN COLLAB DATA AT MT. CHACALTAYA.    1/80*
CC   A   THE VERY HIGH RATE 4/24 OF X-PARTICLE EVENTS MAY BE DUE TO HIGH      1/80*
CC   A   ENERGY OF THE INCIDENT HADRONS (APPROXIMATELY 10**5 GEV).            1/80*

EM       CHARMED HADRON CROSS SEC. IN MISC. EMUL. EXPTS, WHERE LIFETIME SEEN  3/77
EM   J     1 EVENT                      JAIN       75 EMUL TAU APROX. 10E-13  2/77
EM   K     2 EVENTS                     KOMAR      75 EMUL    TAU .LT. E-15   4/77
EM   B     1 EVENT                      BURHOP     76 EMUL    TAU APPROX E-13 3/77
EM   C     0   1.5E-30 OR LESS  CL=.90  COREMANS   76 EMUL    TAU E-12 TO E-14 3/77
EM   N     3 EVENTS (SEMILEPTONIC)      BANNIK     77 EMUL TAU E-13 TO E-15  12/79*
EM   A     1 EVENT                      BANNIK2    77 EMUL TAU APPROX E-14   12/79*
EM   Z     0   7.E-30 OR LESS  CL=.90   BOZZOLI    77       300,400 GEV P-NUCL 1/78
EM   M     0   0.0018 OR LESS  CL=.90   MUNDRA     77 EMUL +- TAU E-12 TO E-14 1/78
EM   A     9 EVENTS                     KOMAR      78 EMUL    TAU=1.2 E-14    1/80*
EM   U     1 EVENT PAIR PROD            USHIDA     78 EMUL 400 GEV P-NUCLEUS  2/79*
EM   L     3 EVENTS                     ALLASIA    79 HYBR TAU APPROX E-13   12/79*
EM   A     1                            ANGELINI   79 HYBR    TAU=2 TO 5 E-13 12/79*
EM   N     2                            ANGELINI2  79 HYBR    NEU BEAM        1/80*
EM   F     1 EVENT (SEMILEPTONIC)       FUCHI      79 EMUL    TAU APPROX E-13 12/79*
EM   I     1 EVENT PAIR PROD            FUCHI2     79 EMUL 400 GEV P-NUCLEUS 12/79*
EM   P     9 EVENTS                     KOMAR      79 EMUL 400 GEV P NUCLEUS 12/79*
EM   R     1 EVENT                      KOMAR2     79 EMUL 200 GEV PI- NUCLEUS 12/79*
EM   J   JAIN 75 IS A FNAL 300 GEV PROTON EXPT. EVENT SHOWS DECAY OF NEUTRAL  2/77
EM   J   INTO HADRON-E-NEU, TAKING PLACE .019 CM FROM THE PROD VERTEX. MAY    2/77
EM   J   BE LEPTONIC DECAY OF CHARMED PARTICLE.                               2/77
EM   K   KOMAR 75 IS FNAL 200 GEV/C PROTON EXPT.  SEE 2 EVENTS WITH SINGLE    4/77
EM   K   ELECTRON EMITTED FROM NEAR INTERACTION.                              4/77
EM   B   BURHOP 76 EXPT DONE AT FERMILAB HIGH ENERGY NEUTRINO BEAM. USED A    3/77
EM   B   COMBINATION OF EMULSION AND SPARK CHAMBERS. THEY SEE A PARTICLE      3/77
EM   B   WITH TAU=ABOUT 6 E-13 SEC DECAYING TO VO + 3 CHGD TRACKS.  DECAY     3/77
EM   B   MODE APPEARS DIFFERENT FROM PREVIOUSLY OBSERVED MODES OF CHARMED     3/77
EM   B   HADRON DECAYS. SEE READ 79 FOR FURTHER ANALYSIS AND DISCUSSION.      7/79*
EM   C   COREMANS 76 USED 300 GEV/C PROTONS, AND LOOKED FOR ABOVE LIFETIMES.  3/77
EM   N   BANNIK 77 USES 70 GEV PROTON BEAM AT SERPUKHOV.                     12/79*
EM   A   BANNIK2 77 USES 60 GEV PI- BEAM AT SERPUKHOV. MASS APPROX 2.4 GEV.  12/79*
EM   Z   BOZZOLI 77 IS FNAL EXPT LOOKING FOR ASSOC PROD OF CHARMED PARTICLES  1/78
EM   Z   WITH TAU=3E-15 TO 3E-13 SECONDS AND MASS LT 4.5 GEV.                 1/78
EM   M   MUNDRA 77 IS FNAL 400GEV P EXPT. ABOVE VALUE IS RATIO TO PI+- PROD.  1/78
EM   A   KOMAR 78 IS 400 GEV/C PROTON EXPT AT FNAL. C.S. APPROX 1E-28 CM**2.  1/80*
EM   U   USHIDA 78 SEES TWO NEUTRALS WITH TAUS 3.02E-14 AND 1.18E-12 IF       2/79*
EM   U   MESONS, 4.21E-14 AND 1.23E-12 IF BARYONS. ASSUMES MESON DECAY MODES  2/79*
EM   U   K-E+NU AND PIO KO, BARYON DECAY MODES XI-E+NU AND PIO XIO.           2/79*
EM   L   ALLASIA 79 USES WIDE BAND NEU BEAM AT CERN. SEES DECAY OF NEUTRAL   12/79*
EM   L   SHORT-LIVED PARTICLE.                                               12/79*
EM   A   ANGELINI 79 IS NEU BEAM EXP AT CERN-SPS. SEE ALSO BURHOP 76.        12/79*
EM   N   ANGELINI2 79 EVENTS INCLUDE LAM/C+ -->PI+K-P WITH ESTIMATED DECAY    1/80*
EM   N   TIME (7.3+-0.1)*E-13 SEC.                                            1/80*
EM   F   FUCHI 79 IS 400 GEV P NUCLEUS EXPT AT FNAL.                         12/79*
EM   I   FUCHI2 79 EVENT GIVES TAU 2.8-4.4E-13. SEE ALSO USHIDA 78.          12/79*
EM   P   KOMAR 79 EVENTS GIVE TAU APPROX 1.5E-14 SEC. CS/NUCLEON=1.2E-28.    12/79*
EM   R   KOMAR2 79 EVENT MAY BE CHARMED BARYON TO E+E- HADRONS VIA N. C.     12/79*

D        CHARMED HADRON PRODUCTION IN NEU NUCLEON INTERACTIONS(RATIO TO C.C.) 1/79*
D    B  64      .007      .002          BALTAY     78 HLBC DO--> KO PI+ PI-   1/79*
D    B  11      .001      .001          BALTAY     78 HLBC D+--> KO PI+       1/79*
D    E          .01   OR LESS           BERGE      78 HBC  DECAY TO LAMBDA PIS 12/79*
D    E          .02   OR LESS           BERGE      78 HBC  DECAY TO KO PIONS 12/79*
D    L   2      0.041     0.024         BLIETSCHA  79 HBC  D*+ PRODUCTION/C.C. 1/80*
D    B   BALTAY 78 IS FNAL EXPT. NO DO SEEN IN N.C. EVENTS.                   1/79*
D    E   BERGE 79 ALSO SET NEU P --> MU- D(--> KO N(PI)) X/C.C. <0.01 AT     12/79*
D    E   CL= 0.9.                                                            12/79*
D    L   BLIETSCHAU 79 IS CERN BEBC EXPT. SEES ONE EVENT NEU P-->MU- P D*+    1/80*
D    L   AND ONE EVENT NEU P-->MU- P D*+ PI+ PI-, WHERE D*+-->DO PI+ IN BOTH  1/80*
D    L   CASES.                                                               1/80*
D            . . . . . . . .
D   AVG         0.0023    0.0024  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7)
D   STUDENT     0.0020    0.0012  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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REFERENCES FOR CHARMED HADRON SEARCHES


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NIU       71 PTP 46 1644       +MIKUMO,MAEDA                    (TOKY+YOKOHAMA)
TASAKA    73 PTP 50 1879       +YAMAMOTO                                (KONA)

AUBERT    75 PRL 35 416        +BECKER,BIGGS,BURGER,CHEN+           (MIT+BNL)
  ALSO    77 MA
BALTAY    75 PRL 34 1118       +CAUTIS,COHEN,CSORNA,KALELKAR + (COLU+BING)
BENVENU1  75 PRL 34 419        BENVENUTI,CLINE,FORD+ (HARV,PENN,WISC,FNAL)
BENVENU2  75 PRL 34 597        BENVENUTI,CLINE,FORD+ (HARV,PENN,WISC,FNAL)
  ALSO    74 PRL 33 984        AUBERT,BENVENUTI+       (HARV,PENN,WISC,FNAL)

BENVENU3  75 PRL 35 1199       BENVENUTI,CLINE,FORD+ (HARV,PENN,WISC,FNAL)
BENVENU4  75 PRL 35 1203       BENVENUTI,CLINE,FORD+ (HARV,PENN,WISC,FNAL)
BENVENU5  75 PRL 35 1249       BENVENUTI,CLINE,FORD+ (HARV,PENN,WISC,FNAL)
BLESER    75 PRL 35 76         +GOBBI,KENAH,KEREN+    (FNAL+NWES+ROCH+SLAC)
CARLSSON  75 NP B99 451        +EKSPONG,HOLMGREN,NILSSON+        (STOH+LIVP)
DEDEN     75 PL 58B 361              (AACH+BRUX+CERN+EPOL+MILA+ORSA+LOUC)

JAIN      75 PRL 34 1238       P. L. JAIN, B. GIRARD                    (BUFF)
KOMAR     75 JETPL 21 239      +ORLOVA,TRETYAKOVA,CHERNYAYSKII          (LEBD)
  ALSO    76 SJNP 24 275       KOMAR,ORLOVA,TRETYAKOVA,CHERNYAVSKII     (LEBD)
SUGIMOTO  75 PTP 53 1540       +SATO,SAITO                         (TWAS+TOKY)
WARD      75 NP B101 29        +ANSORGE,CARTER,MOUNT,NEALE+            (CAVE)

AAHLIN    76 NP B107 476       +ALPGARD,ANDERSEN,BERGVATN+(OSLO+STOH+HELS)
ABOLINS   76 PRL 37 417        +CARDIMONA,MATTHEWS,SIDWELL+ (MSU+GSU+CARL)
ALBROW    76 NP B114 365       CERN+DARE+FOM+LANC+LIVP+MCHS+RHEL+UTR+LUND
APEL      76 SJNP 24 507       +BERTOLUCCI,VIKTOROV,VINCELLI+    (SERP+CERN)
BARISH    76 PRL 36 939        +BARTLETT,BODEK,BROWN,BUCHHOLZ +  (CIT+FNAL)
BINKLEY   76 PRL 37 578        +GAINES,PEOPLES,KNAPP+  (FNAL+COLU+HAWA+ILL)

BINTINGE  76 PRL 37 732        BINTINGER,LUNDY,AKERLOF+    (FNAL+MICH+PURD)
BLIETSCH  76 PL 60B 207              (AACH+BRUX+CERN+EPOL+MILA+ORSA+LOUC)
BUNNELL   76 PRL 37 85         +CHENG,DELPAPA,DORFAN,DCUNGVAN+  (UCSC+SLAC)
BURHOP    76 PL 65B 299        (LOUC+FNAL+BELG+DUUC+CERN+LOIC+ROMA+STRB+)
CESTER    76 PRL 37 1178       +FITCH,KADEL,WEBB,WHITTAKER +      (PRIN+BNL)
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

OTHER STABLE PARTICLE SEARCHES


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COREMANS 76 PL 65B 480       +SACTON+     (BELG+DUUC+LOUC+ROMA+STRB+WARS)
GHIDINI  76 NP B111 189      +NAVACH,DOWELL,KENYON+          (OMEGA GROUPS)
HAGOPIAN 76 PRL 36 296       +WILKINS,WIND,HAGOPIAN,ALBRIGHT+ (FSU+BRAN)
KLEMS    76 APP B7 497       +KO,LANDER,PELLETT+     (UCD+CRAC+WASH+WARS)
KNAPP    76 PRL 37 882       +LEE,LEUNG,SMITH +      (COLU+HAWA+ILL+FNAL)
QUINN    76 PR D14 2857      D. J. QUINN, R. H. MILBURN              (TUFTS)
VONKROGH 76 PRL 36 710       +FRY,CAMERINI,CLINE+    (WISC+LBL+CERN+HAWA)

ALDER    77 PL 66B 401       +BLOCK+ (AACH+UCR+CERN+HARV+LAUS+MUNC+NWES)
ASRATYAN 77 PL 71B 439       +EPSTEIN,GRIGORIEV,KALGANOV +     (ITEP+SERP)
BALLAGH  77 PRL 39 1650      +BINGHAM,BOSETTI,FRETTER+    (LBL+HAWA+WASH)
BALTAY   77 PRL 39 62        +HIBBS,HYLTON,KALELKAR,DRANCE +   (COLU+BNL)
BANNIK   77 JETPL 25 550     +BOBODZHANOV,SALOMOV,SUNTSZINYAN+     (JINR)
BANNIK2  77 JETPL 26 275     +BOBODZHANOV,LESKIN,MUKHTAROV+        (JINR)
BARISH   77 PR D15 1         +DERRICK,DOMBECK,MUSGRAVE +       (ANL+PURD)
BARISH2  77 PRL 39 981       +BARTLETT,BODEK,BROWN +      (CIT+FNAL+ROCK)
BAUM     77 PL 68B 279       +BLOCK,BOHM+ (AACH+UCR+CERN+HARV+MUNC+NWES)

BERGE    77 PRL 38 266       +DIBIANCA,EMANS +       (FNAL+SERP+ITEP+MICH)
BLANAR   77 PRL 38 192       +BOYER,FAISSLER,GARELICK,GETTNER +    (NEAS)
BLETZACK 77 PRL 38 1241      BLETZACKER,NIEH,SONI              (STON+UCSB)
BOSETTI  77 PRL 38 1248      +GALTIERI,LYNCH +       (LBL+CERN+HAWA+WISC)
BOZZOLI  77 LNC 19 32        +CAMPANINI,CAPILUPPI,GESSAROLI+ (BGNA+FIRZ)
BRANDEL2 77 PL 70B 387       BRANDELIK +       (AACH+DESY+HAMB+MPIM+TOKY)

BRANSON  77 PRL 38 580       +SANDERS,SMITH,THALER,ANDERSON+   (PRIN+EFI)
DEDEN    77 PL 67B 474       +         (AACH+BELG+CERN+EPOL+MILA+LALO+LOUC)
DITZLER  77 PL 71B 451       +FINLEY,JOHNSON,LOEFFLER + (PURD+MICH+FNAL)
GODDARD  77 PR D16 2730      +GILBERT,KEY,GORDON,LAI            (TNTO+BNL)
HAIDT    77 JPG 3 1                    (BERKELEY+CERN+HAWAII+WISCONSIN)

HOLDER   77 PL 69B 377       +KNOBLOCH,MAY+    (CERN+DORT+HEID+SACL+BGNA)
HOLDER2  77 PL 70B 396       +KNOBLOCH,MAY+    (CERN+DORT+HEID+SACL+BGNA)
JONCKHEE 77 PR D16 2073      JONCKHEERE,COOK,CSORNA +     (WASH+LALO+UCD)
    ALSO 76 PL 64B 221       COOK,CSORNA,HOLMGREN+        (WASH+LALO+UCD)
MA       77 PRL 38 172       MA,OH                                  (MSU)
MUNDRA   77 LNC 18 554       +PUTT,STUTELEY,YOCK                   (AUCK)
PICCOLO  77 PRL 39 1503      +PERUZZI,LUKE,LUTH+     (SLAC+LBL+NWES+HAWA)

ABOLINS  78 PL 73B 355       +MATTHEWS,SIDWELL +     (MSU+CARL+FNAL+CSU)
ALIBRAN  78 PL 74B 134        (AACH+BARI+BERG+BRUX+CERN+EPOL+MILA+ORSA+)
ANTIPOV  78 JETPL 28 457     +BEZZUBOV,BUDANOV,BUSHNIN,GORIN+      (SERP)
ANTIPOV2 78 JETPL 28 461     +BEZZUBOV,BUDANOV,GORIN,DENISENKO+    (SERP)
ASRATYAN 78 PL 79B 497       +EPSTEIN,FAKHRUTDINOV+           (ITEP+SERP)
BALLAM   78 PRL 40 741       +BOUCHEZ,CARROLL,CHADWICK+ (SLAC+DUKE+LOIC)
BALTAY   78 PRL 41 73        +CAROUMBALIS,FRENCH,HIBBS,HYLTON+(COLU+BNL)
BAUM     78 PL 77B 337       +BLOCK,BOEHM+(AACH+UCR+CERN+HARV+MUNC+NWES)
BBDMPST  78 SJNP 28 340      BERL+BUDA+DUBNA+MOSCOW+PRAG+SOFI+TBILISI
BENVENUT 78 PRL 41 725       BENVENUTI+   (FNAL+HARV+OSU+PENN+RUTG+WISC)
    ALSO 78 PRL 41 1204      BENVENUTI+   (FNAL+HARV+OSU+PENN+RUTG+WISC)
BERGE    78 PR D18 1359      +BOGERT,CUNDY,DIBIANCA+(FNAL+UCB+HAWA+MICH)
BOSETTI1 78 PL 73B 380       +DEDEN +       (AACH+BONN+CERN+LOIC+OXF+SACL)
BOSETTI2 78 PL 74B 143       +DEDEN +       (AACH+BONN+CERN+LOIC+OXF+SACL)

CESTER   78 PRL 40 139       +FITCH,KADEL,WEBB,WHITTAKER +     (PRIN+BNL)
CLARK    78 PL 77B 339       +DARRIULAT,EGGERT +         (CERN+SACL+ZURI)
ERRIQUEZ 78 PL 77B 227            BARI+BIRM+BRUX+EPOL+RHEL+SACL+LOUC
FELLER   78 PRL 40 1677      +LITKE,MADARAS,RONAN+  (LBL+SLAC+NWES+HAWA)
FERGUSON 78 PL 79B 161       +BUCHANAN,NODULMAN,POSTER +      (UCLA+SLAC)
    ALSO 79 PR D19 1935      FERGUSON+BUCHANAN,NODULMAN +     (UCLA+SLAC)

HANSL    78 PL 74B 139       +HOLDER,KNOBLOCH+(CERN+DORT+HEID+SACL+BGNA)
JACHOLKO 78 NP B142 53       JACHOLKOWSKA+     (ORSA+BELG+CERN+LOIC+MONS)
KOMAR    78 JETPL 28 453     +ORLOVA,SALMANOVA,TRETYAKOV+          (LEBD)
LAUTERBA 78 PR D17 2507      M.J.LAUTERBACH                        (YALE)
LIPTON   78 PRL 40 608       +GOBBI,KEREN,ROSEN,RUCHTI+ (NWES+ROCH+FNAL)
SPELBRIN 78 PRL 40 605       SPELBRING,GOBBI,KEREN +     (NWES+ROCH+FNAL)
USHIDA   78 LNC 23 577       +FUCHI,HOSHINO+        (AICHI+NAGOYA+YOKOHAMA)

ALLASIA  79 PL 87B 287       TORI+PISA+ROMA+LOUC+BRUX+DUBLIN+CERN+ANKA+
ANGELINI 79 PL 80B 428       ANKA+BRUX+CERN+DUBLIN+LOUC+KEYNES+PISA+
ANGELIN2 79 PL 84B 150       ANKA+BRUX+CERN+DUBLIN+LOUC+KEYNES+PISA+
ARMENISE 79 PL 86B 115       +ERRIQUEZ+        (BARI+CERN+EPOL+MILA+ORSA)
ATIYA    79 PRL 43 414       +HOLMES,KNAPP,LEE+           (COLU+ILL+FNAL)
BARANOV  79 PL 81B 261       +IVANILOV,KONYUSHKO,KORABLEV+         (SERP)
BAUER    79 PRL 43 1551      +KILEY,BALL,CHANG,CHEN,GHODS+     (MSU+FNAL)
BBDMPSST 79 SJNP 29 46       BERL+BUDA+DUBNA+MOSC+PRAG+SERP+SOFIA+TBILI

BERGE    79 PL 81B 89        +BOGERT,ENDORF,HANFT+ (FNAL+SERP+ITEP+MICH)
BLIETSCH 79 PL 86B 108       BLIETSCHAU+          (AACH+BONN+CERN+MPIM+OXF)
BRANSON  79 PR D20 337       +MCDONALD,SANDERS,SMITH,THALER+   (PRIN+EFI)
BROWN    79 PRL 43 410       +BARISH,BARTLETT,BODEK,SHAEVITZ+ (CIT+STAN)
CHILINGA 79 PL 83B 136       CHILINGAROV,CLARK+            (CERN+SACL+ETH)
    ALSO 79 NP B151 29       CHILINGAROV,CLARK+            (CERN+SACL+ETH)

COTEUS   79 PRL 42 1438      +DIESBURG,FINE,LEE,SOKOLSKY+ (COLU+ILL+BNL)
DEGROOT  79 PL 86B 103       +HANSL,HOLDER     (CERN+DORT+HEID+SACL+BGNA)
DIAMANTB 79 PRL 43 1774      DIAMANT-BERGER,DISHAW,FAESSLER+  (STAN+CIT)
DISHAW   79 PL 85B 142       +DIAMANT-BERGER,FAESSLER,LIU+    (SLAC+CIT)
DRIJARD  79 PL 81B 250       +FISCHER,GEIST+         (CERN+CDEF+HEID+KARL)
DRIJARD2 79 PL 85B 452       +FISCHER+    (CERN+CDEF+DORT+HEID+LAPP+WARS)

FUCHI    79 NC 51A 18        +HOSHINO,KURAMATA+  (NAGOYA+AICHI+YOKOHAMA)
FUCHI2   79 PL 85B 135       +HOSHINO,KURAMATA,NIU+  (NAGOYA+AICHI+YOKO)
GIBONI   79 PL 85B 437       AACH+CERN+HARV+MUNC+NWES+UCR COLLABORATION
KOMAR    79 SJNP 29 40       +ORLOVA,SALMANOVA,TRETYAKOVA +        (LEBD)
KOMAR2   79 SJNP 29 50       +ORLOVA,TRETYAKOVA,CHERNYAVSKII       (LEBD)
LOCKMAN  79 PL 85B 443       +MEYER,RANDER,SCHLEIN,WEBB+      (UCLA+SACL)
READ     79 PR D19 1287        (FNAL+BELG+DUUC+LOIC+LOUC+KEYN+MULHOUSE+)
SAWAYANA 79 PR D20 1037      K. SAWAYANAGI                       (WASEDA)

ADAMOVIC 80 PL 89B 427       (PHOTON-EMUL. COLLAB., OMEGA-PHOTON COLLAB.)
BALLAGH  80 PL 89B 423       +BINGHAM+     (UCB,LBL,FNAL,HAWA,WASH,WISC)

                             REVIEWS REFERRED TO IN DATA CARDS

GAISSER  76 PR D14 3153      T.K.GAISSER,F.HALZEN               (BART+WISC)

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OTHER STABLE PARTICLE SEARCHES

We collect here those searches which do not fit neatly into one of the above search categories. These include axion searches (section AX), trimuon and four-lepton production in neutrino and antineutrino reactions (T, FL), and heavy particle searches in accelerator experiments (CH, CS, D, ICH) and in cosmic rays (F).

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AX      AXION PRODUCTION RATIO TO PIO PROD CROSS-SEC.                     6/78*
AX       FOR THEORY AND REVIEW SEE WEINBERG PRL 40, 223 (1978), WILCZEK
AX       PRL 40, 279 (1978), AND DONNELLY PR D18, 1607 (1978).
AX          1. E-8    OR LESS  CL=.90   ALIBRAN   78 HYBR   BEAM DUMP      6/78*
AX          6. E-9    OR LESS  CL=.95   ASRATYAN  78 CALO   BEAM DUMP     12/79*
AX    F     5.4E-14   OR LESS  CL=.90   BELLOTTI  78 HLBC   FOR MASS=1.5 MEV  1/79*
AX    F     4.1E- 9   OR LESS  CL=.90   BELLOTTI  78 HLBC   FOR MASS=1 MEV  1/79*
AX    F     1.5E- 8   OR LESS  CL=.90   BELLOTTI  78 HLBC   BEAM DUMP      1/79*
AX    B     1. E-8    OR LESS  CL=.90   BOSETTI   78 HYBR   BEAM DUMP      6/78*
AX    D                                 DONNELLY  78                      12/79*
AX          0.5E-8    OR LESS  CL=.90   HANSL     78 WIRE   BEAM DUMP      6/78*
AX    M                                 MICELMACH 78                      12/79*
AX    V                                 VYSOTSSKI 78                       1/80*
AX    L                                 BECHIS    79 CNTR                 12/79*
AX    C     1. E-8    OR LESS  CL=.90   COTEUS    79 OSPK   BEAM DUMP      7/79*
AX    H     1. E-3    OR LESS  CL=.95   DISHAW    79 CALO   400 GEV P P   12/79*
AX    F  BELLOTTI 78 FIRST VALUE COMES FROM SEARCH FOR A-->E+E-. SECOND    1/79*
AX    F  VALUE COMES FROM SEARCH FOR A-->2GAMMA, ASSUMING MASS<2*MASS(E-). 1/79*
AX    F  FOR ANY MASS SATISFYING THIS,LIMIT IS ABOVE VALUE*(MASS**-4).     1/79*
AX    F  THIRD VALUE USES DATA OF PL 60B 401 AND QUOTES CS(PROD)*CS(INTER- 1/79*
AX    F  ACTION)<10**-67 CM**4.                                            1/79*
AX    B  BOSETTI 78 QUOTES CS(PROD)*CS(INTERACT)< 2.E-67 CM**4             6/78*
AX    D  DONNELLY 78 EXAMINES DATA FROM REACTOR NEUTRINO EXPTS OF REINES 76 12/79*
AX    D  AND GURR 74 AS WELL AS SLAC BEAM DUMP EXPT. EVIDENCE IS NEGATIVE. 12/79*
AX    M  MICELMACHER 78 FINDS NO EVIDENCE OF AXION EXISTENCE IN REACTOR   12/79*
AX    M  EXPTS OF REINES 76 AND GURR 74. (SEE REF UNDER DONNELLY 78 BELOW). 12/79*
AX    V  VYSOTSSKII 78 DERIVED LOWER LIMIT FOR THE AXION MASS. 25 KEV FROM  1/80*
AX    V  LUMINOSITY OF THE SUN AND 200 KEV FROM RED SUPERGIANTS.           1/80*
AX    L  BECHIS 79 LOOKED FOR THE AXION PRODUCTION IN LOW ENERGY ELECTRON 12/79*
AX    L  BREMSSTRAHLUNG AND THE SUBSEQUENT DECAY INTO EITHER 2 GAMMAS OR  12/79*
AX    L  E+ E-. NO SIGNAL FOUND. C.L.=0.90 LIMITS FOR MODEL PARAMETER(S)  12/79*
AX    L  ARE GIVEN.                                                       12/79*
AX    C  COTEUS 79 IS A BEAM DUMP EXPERIMENT AT BNL.                      12/79*
AX    H  DISHAW 79 IS A CALORIMETRIC EXPERIMENT AND LOOKS FOR LOW ENERGY  12/79*
AX    H  TAIL OF ENERGY DISTRIBUTUIONS DUE TO ENERGY LOST TO WEAKLY       12/79*
AX    H  INTERACTING PARTICLES.                                           12/79*

T       TRIMUON PRODUCTION IN NEUTRINO NUCLEON INTERACTIONS
T        SEE ALSO SECTION 'NEU' IN 'HEAVY LEPTON SEARCHES' AND
T        SECTION 'Y' IN 'CHARMED HADRON SEARCHES'. FOR EXTENSIVE DISCUSSION,
T        SEE ALBRIGHT 78 (PR D18, 108), HANSL 78 (NP B142, 381), AND KANE 79
T        (PR D19, 1978).
T     R   2 EVENTS MU- MU MU            BARISH    77 SPEC    NEU BEAM        7/77
T     R  BARISH 77 EVENTS CONTAIN FAST MU- AND 2 ADDITIONAL MUONS WITH LOW    7/77
T     R  ENGERY IN DIMUON REST FRAME. SLOW MUONS COULD COME FROM EITHER       7/77
T     R  VIRTUAL PHOTON OR VECTOR MESON OR FROM ASSOC PROD OF CHARMED         7/77
T     R  PARTICLES WHICH DECAY LEPTONICALLY.                                  7/77
T     E   6 SEEN                        BENVENUTI 77 NEUL    5/6NEU,1/6NEUBAR 12/77
T     E  BENVENUTI 77 IS FNAL EXPT. CAN BE EXPLAINED BY PROD OF NEW HEAVY    12/77
T     E  LEPTON --> MU- NEUBAR NEW LIGHTER LEPTON --> MU+ MU- NEU.           12/77
T     L                                 BLETZACKE 77 RVUE                   12/77
T     L  BLETZACKER 77 EXPLAINS TRIMUON AND LIKE SIGN DIMUON PROD AS ASSOC   12/77
T     L  PROD OF CHARM.                                                      12/77
T     H   3 SEEN                        HOLDER    77 SPEC                   12/77
T     H  HOLDER 77 EVENTS ARE MU-MU-M+ AND MU-MU+MU+ WITH NEU BEAM, AND      12/77
T     H  MU+MU-MU- WITH NEUBAR BEAM. RATE RELATIVE TO CHARGED CURRENT EVENTS 12/77
T     H  IS 4*10**-5.                                                        12/77
T     I                                 ALBRIGHT  78 RVUE                   12/79*
T     I  ALBRIGHT 78 COMPARES DATA OF TRIMUON AND FOUR-MUON EVENTS LISTED    12/79*
T     I  ABOVE WITH SIX MODELS.                                              12/79*
T     B   7 SEEN                        BENVENUTI 78 NEUL                    8/78*
T     B  BENVENUTI 78 IS FNAL EXPT. 6 OF THE EVENTS ARE SEEN USING A 95 PCNT  8/78*
T     B  NEU BEAM, 1 USING AN 83 PCNT NEUBAR BEAM. SEE MORI 78 FOR LIMITS     8/78*
T     B  OF THE PROB THAT THE TRIMUONS ARE PRODUCED BY A NEW SHORT-LIVED      8/78*
T     B  SOURCE OF NEUTRINOS.                                                 8/78*
T     A  76 EVENTS MU- MU- MU+          HANSL2    78 SPEC    NEU BEAM        1/79*
T     A  HANSL2 78 IS CERN SPS EXPT. RATE RELATIVE TO SINGLE MUON EVENTS IS   1/79*
T     A  (3.0+-.4)*10**-5 FOR E(NEU)>30 GEV. CAN BE EXPLAINED AS C.C.         1/79*
T     A  INTERACTIONS WITH ADDITIONAL LOW MASS MU PAIRS. NO EVIDENCE FOR NEW  1/79*
T     A  HEAVY LEPTON.                                                        1/79*
T     N  39 MU-MU-MU+ SEEN              BENVENUTI 79 NEUL    NEU BEAM        7/79*
T     N  BENVENUTI 79 INCLUDES 9 EVENTS FROM BENVENUTI 77 AND 78. RATE        7/79*
T     N  RELATIVE TO SINGLE MUON EVENTS IS (1.1+-.5)*10**-4 FOR E(NEU)>100    7/79*
T     N  GEV.  CONSISTENT WITH E.M. AND DIRECT PRODUCTION OF MU PAIRS.        7/79*
T     N  CHARM ASSOC PROD MAY ACCOUNT FOR 20 PERCENT OF PRODUCTION.  NO       7/79*
T     N  EVIDENCE FOR NEW HEAVY LEPTONS OR HEAVY QUARKS.                      7/79*
T     D   8 MU+MU+MU-                   DEGROOT   79 SPEC    NEUBAR BEAM    12/79*
T     D  DEGROOT 79 IS CERN SPS EXPT. RATE RELATIVE TO SINGLE MUON EVENTS    12/79*
T     D  IS (1.8+-0.6)E-5 FOR E(NEU)>=30 GEV AND P(MU)>=4.5 GEV/C. COULD BE  12/79*
T     D  EXPLAINED AS C.C. INTERACTION ACCOMPANIED BY A MUON PAIR OF EITHER  12/79*
T     D  HADRONIC OR E.M. ORIGIN AS IN NEU CASE. NEGATIVE SIGNAL FOR HEAVY   12/79*
T     D  LETPON.                                                             12/79*

FL      FOUR-LEPTON PRODUCTION IN NEUTRINO-NUCLEON INTERACTIONS               2/79*
FL    H   1 2MU+ 2MU-                   HOLDER    78 SPEC                    2/79*
FL    L   1 2E- E+ MU+                  LOVELESS  78 HBC                     2/79*
FL    H  HOLDER 78 EVENT IS FROM CERN-SPS EXPT. RATE RELATIVE TO MU+MU-      2/79*
FL    H  EVENTS IS 1.4E-4.                                                   2/79*
FL    L  LOVELESS 78 EVENT IS FROM FNAL EXPT. EVENT ALSO HAS 1 KOS AND 7     2/79*
FL    L  GAMMAS.                                                             2/79*
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Stable Particles

OTHER STABLE PARTICLE SEARCHES

Data Card Listings

For notation, see key at front of Listings.

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MU      DI- AND TRI-MUON PRODUCTION IN MU NUCLEON INTERACTIONS
MU   C   11 TRIMUON EVENTS                   CHANG      77 SPEC                    12/77
MU   C   32 DIMUON EVENTS                    CHANG      77 SPEC                    12/77
MU   C  CHANG 77 DIMUON RATE IS GT 5*10**-4 THAT OF INCLUSIVE MUON RATE.           12/77
MU   C  CROSS SECTION UNCORRECTED FOR ACCEPTANCE IS 5*10**-36 CM**2/NUCLEON         12/77

CH      HEAVY PARTICLE PRODUCTION CROSS SECTION (CM**2)
CH   L   0  1. E-31 OR LESS                  LEIPUNER   73 CNTR +- M=3-11 GEV       5/76
CH   C     .3-1.3E-31 OR LESS                CARROLL    78 SPEC    M=2.-2.5 GEV     1/79*
CH   L  LEIPUNER 73 IS AN NAL 300 GEV P EXPT. WOULD HAVE DETECTED PARTICLES        4/76
CH   L  WITH LIFETIME GREATER THAN 200 NSEC.                                        4/76
CH   C  CARROLL 78 LOOK FOR NEUTRAL, S=-2 DIHYPERON RESONANCE IN                    1/79*
CH   C  P P --> 2K+ X. CS VARIES WITHIN ABOVE LIMITS OVER MASS RANGE AND            1/79*
CH   C  PLAB=5.1-5.9 GEV/C.                                                         1/79*

CS      HEAVY PARTICLE PRODUCTION CROSS-SECTION (CM**2/NUCLEON)
CS   G   0  2.5E-35 OR LESS                  GUSTAFSON 76 CNTR 0  TAU GT 10**-7     1/77
CS   G  GUSTAFSON 76 IS A 300 GEV FNAL EXPT LOOKING FOR HEAVY (M GT 2 GEV)         1/77
CS   G  LONGLIVED NEUTRAL HADRONS IN THE M4 NEUTRAL BEAM. THE ABOVE TYPICAL        1/77
CS   G  VALUE IS FOR M=3 GEV AND ASSUMES AN INTERACTION CROSS SECTION OF           1/77
CS   G  1 MB.  VALUES AS A FUNCTION OF MASS AND INTERACTION CROSS SECTION          1/77
CS   G  ARE GIVEN IN FIG. 2.                                                        1/77

D       HEAVY PARTICLE PRODUCTION DIFFERENTIAL CROSS SECTION (CM**2/SR-GEV)
D    D   0  1.5E-36 OR LESS                  DORFAN     65 CNTR BE TARGET  M=3-7GEV  5/76
D    D   0  3.0E-36 OR LESS                  DORFAN     65 CNTR FE TARGET  M=3-7GEV  5/76
D        0  2.4E-35 OR LESS   CL=.90         BINON      69 CNTR Q=- M=1-1.8 GEV      3/77
D    S   0  2.4E-35 OR LESS   CL=.90         ANTIPOV1   71 CNTR Q=- M=1.2-1.7,2.1-4  3/77
D    T   0  1.2E-35 OR LESS   CL=.90         ANTIPOV2   71 CNTR Q=- M=2.2-2.8        3/77
D    L   0  5.8E-34 OR LESS   CL=.90         ALPER      73 SPEC +- M=1.5-24 GEV      5/76
D    A   0  1. E-31 OR LESS   CL=.90         APPEL      74 CNTR +- M=3.2-7.2 GEV     2/76
D    W   0  2.2E-33 OR LESS   CL=.90         ALBROW     75 SPEC Q=+-1  M=4-15 GEV    1/77
D    W   0  1.1E-33 OR LESS   CL=.90         ALBROW     75 SPEC Q=+-2  M=6-27 GEV    1/77
D    J   0  8. E-35 OR LESS   CL=.90         JOVANOVIC 75 CNTR +- M=15-26 GEV        2/76
D    J   0  1.5E-34 OR LESS   CL=.90         JOVANOVIC 75 CNTR Q=+-2, M=3-10 GEV     2/76
D    J   0  6. E-35 OR LESS   CL=.90         JOVANOVIC 75 CNTR Q=+-2, M=10-26 GEV    2/76
D    B   0  2.6E-36 OR LESS   CL=.90         BALDIN     76 CNTR Q=-1, M=2.1-9.4 GEV  1/77
D    D  DORFAN 65 IS A 30 GEV/C P EXPT AT BNL.  UNITS ARE PER GEV MOMENTUM         5/76
D    D  PER NUCLEUS.                                                                5/76
D    S  ANTIPOV1 71 LIMIT INFERRED FROM FLUX RATIO. 70 GEV P EXPERIMENT.            3/77
D    T  ANTIPOV2 71 IS FROM SAME 70 GEV P EXP. AS ANTIPOV1 71 AND BINON 69.         3/77
D    L  ALPER 73 IS CERN ISR 26+26 GEV P+P EXPT.  P>.9 GEV, .2< BETA <.65.          5/76
D    A  APPEL 74 IS NAL 300 GEV P+W EXPERIMENT. STUDIES FORWARD PRODUCTION          2/76
D    A  OF HEAVY (UP TO 24 GEV) CHARGED PARTICLES WITH MOMENTA 24-200GEV(-)         2/76
D    A  AND 40-150GEV (+CHG). ABOVE TYPICAL VALUE IS FOR 75 GEV AND IS              5/76
D    A  PER GEV MOMENTUM PER NUCLEON.                                               5/76
D    W  ALBROW 75 IS A CERN ISR EXPT WITH ECM=53 GEV. THETA=40 MR. SEE              1/77
D    W  FIG. 5 FOR MASS RANGES UP TO 35 GEV.                                        1/77
D    J  JOVANOVICH 75 IS A CERN ISR 26+26 AND 15+15 GEV P+P EXPERIMENT.             2/76
D    J  FIG.4 COVERS RANGES Q=1/3 TO 2 AND M=3 TO 26 GEV.                           2/76
D    J  VALUE IS PER GEV MOMENTUM.                                                  5/76
D    B  BALDIN 76 IS A 70 GEV SERP EXP.  VALUE IS PER AL NUCLEUS AT                 1/77
D    B  THETA=0.  FOR OTHER CHARGES IN RANGE -0.5 TO -3.0, CL=.90 LIMIT IS          1/77
D    B  (2.6E-36)/ABS(CHARGE) FOR MASS RANGE (2.1 TO 9.4GEV)*ABS(CHARGE).           1/77
D    B  ASSUMES STABLE PARTICLE INTERACTING WITH MATTER AS DO ANTIPROTONS.          1/77

ICH     LONGLIVED HEAVY PARTICLE INVARIANT C.S. (CM**2/GEV**2/NUCLEON)             1/79*
ICH  C   0  1.1E-37 OR LESS   CL=.90         CUTTS      78 CNTR MASS=4-10 GEV       1/79*
ICH  V   0  3.0E-37 OR LESS   CL=.90         VIDAL      78 CNTR MASS=4.5-6 GEV     12/79*
ICH  A   0  6. E-33 OR LESS   CL=.90         ARMITAGE   79 SPEC     M=1.87 GEV      7/79*
ICH  A   0  1.5E-33 OR LESS   CL=.90         ARMITAGE   79 SPEC     M=1.5-3.0 GEV   7/79*
ICH  B   0                                   BOZZOLI    79 CNTR Q=+-(2/3,1,4/3,2)   1/80*
ICH  C  CUTTS 78 IS P BE EXPT AT FNAL SENSITIVE TO PARTICLES OF TAU>5E-8SEC         1/79*
ICH  C  VALUE IS FOR -.3<X<0 AND PT=0.175.
ICH  V  VIDAL 78 IS FNAL 400 GEV PROTON EXPT. VALUE IS FOR X=0 AND PT=0.            2/79*
ICH  V  PUTS LIFETIME LIMIT OF <5*10**-8 SEC ON PARTICLE IN THIS MASS RANGE         2/79*
ICH  A  ARMITAGE 79 IS CERN-ISR EXPT AT ECM=53 GEV. VALUE IS FOR X=0 AND            7/79*
ICH  A  PT=0.15. OBSERVED PARTICLES AT M=1.87 GEV ARE FOUND ALL CONSISTENT          7/79*
ICH  A  WITH BEING ANTIDEUTERONS.                                                   7/79*
ICH  B  BOZZOLI 79 IS CERN-SPS 200 GEV P N EXPERIMENT. LOOKS FOR PARTICLE           1/80*
ICH  B  WITH TAU LARGER THAN 10**-8 SEC. SEE THEIR FIG.11-18 FOR PRODUCTION         1/80*
ICH  B  CROSS SECTION UPPER LIMITS VS MASS.                                         1/80*

CA      CROSS-SEC FOR PROD AND CAPT OF LONG-LIVED MASSIVE PARTICLES (CM**2)
CA   F   0    .1-9E-36 OR LESS               FRANKEL    74 CNTR TAU=1 TO 1000 HRS   7/76
CA   R   0  1.4-9E-36 OR LESS                FRANKEL    75 CNTR TAU=50 MS TO 10 HRS 2/77
CA   A   0    2-20E-34 OR LESS               ALEKSEE1   76 ELEC TAU=100 MS TO 1 DAY 4/77
CA   A   0    .2-8E-34 OR LESS               ALEKSEE2   76 ELEC TAU=5 MS TO 1 DAY   3/77
CA   F  FRANKEL 74 LOOKS FOR PARTICLES PRODUCED IN THICK AL TARGETS BY              7/76
CA   F  300-400 GEV/C PROTONS.                                                      7/76
CA   R  FRANKEL 75 IS EXTENSION OF FRANKEL 74.                                      2/77
CA   A  ALEKSEEV(1,2) 76 ARE 61-70 GEV P SERP EXPT. CS IS PER PB NUCLEUS.           3/77

F       HEAVY PARTICLE FLUX IN COSMIC RAYS (NUMBER/CM**2-SEC-SR)
F        0  3.0E-10 OR LESS                  BJORNBOE   68 CNTR     M ABOVE 5 GEV   4/77
F        0  5.0E-11 OR LESS   CL=.90         JONES      67 ELEC     M=5 TO 15 GEV   3/77
F        0  3.0E-8  OR LESS                  DARDO      72 CNTR                     4/77
F        0  1.5E-9  OR LESS                  TONWAR     72 CNTR     M GT 10 GEV     4/77
F    Y   5  6. E-9  OR MORE                  YOCK       74 CNTR     M GT 6 GEV      1/76
F        0  7. E-10 OR LESS   CL=.90         YOCK       75 ELEC +- Q GT 7 OR LT -7E 9/76
F        0  1.0E-9  OR LESS                  BRIATORE   76 ELEC                     4/77
F    B      1.3E-9  OR LESS   CL=.90         BHAT       78 CNTR +- M GT 1 GEV       1/80*
F        3  4.3+-1.3 E-11                    GOODMAN    79 ELEC     M>= 5 GEV       7/79*
F    Y  YOCK 74 EVENTS COULD BE TRITONS.                                            1/76
F    B  BHAT 78 IS AT KOLAR GOLD FIELDS. LIMIT IS FOR TAU > 10**-6 SEC.             1/80*

C       LIGHT (BETWEEN MU AND E MASSES) PARTICLE MASS(UNITS-ELECTRON MASSES)
C        0    NONE BETWEEN 6 AND 25      BELOUSOV  60 CNTR  SPINOR,TAU>1 E-8        5/76
C        0    NONE BETWEEN 2 AND 25      GORBUNOV  60 CC    SPINOR,TAU>1 E-9        5/76
C        0    NONE BETWEEN 5 AND 175     COWARD    63 CNTR  SPINOR,TAU>22 E-10      5/76
C        0    NONE BETWEEN 5 AND 175     COWARD    63 CNTR  SCALAR,TAU>68 E-10      5/76
C    D   0    NONE BETWEEN 2 AND 13      BLAGOV    75 CNTR SPINOR,TAU>2E-10SEC      2/76
C    D   0    NONE BETWEEN 2 AND 10.6    BLAGOV    75 CNTR SCALAR,TAU>2E-10SEC      2/76
C    V   0    NONE BETWEEN 120 AND 190 VIERTEL     78 CNTR TAU >2.E-5 SEC           1/80*
C    D  BLAGOV 75 BOUNDS ON LIFETIME DEPEND ON MASS AND IMPROVE AS MASS             4/77
C    D  DECREASES.  AT 2 GEV THE EXPERIMENT IS SENSITIVE TO TAU>3E-11 SEC           4/77
C    D  FOR SPINOR, TAU>5E-11 SEC FOR SCALAR.                                       4/77
C    V  VIERTEL 78 SEARCHES FOR MU+ -->X+ NEU. FINDS BR<2.E-6 IN MASS               1/80*
C    V  RANGE GIVEN ABOVE (CL=.90)                                                  1/80*

CON     CONCENTRATION OF HEAVY STABLE PARTICLES IN MATTER                           7/79*
CON   2.E-22 TO 1.E-21 OR LESS           SMITH      79 SPEC WATER,M=6-350 MPROT     7/79*

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REFERENCES FOR OTHER NEW PARTICLE SEARCHES


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BELOUSOV 60 JETP 11 1143     +RUSAKOV,TAMM,CERENKOV                       (LEBD)
GORBUNOV 60 JETP 11 51       +SPIRIDONOV,CERENKOV                         (LEBD)
COWARD   63 PR 131 1782      +GITTELMAN,LYNCH,RITSON                      (STAN)
DORFAN   65 PRL 14 999       +EADES,LEDERMAN,LEE,TING                     (COLU)
JONES    67 PR 164 1584        (MICH+WISC+LBL+UCLA+MINN+COSU+COLO+MURA)

BJORNBOE 68 NC 853 241       +DAMGARD,HANSEN,CHATTERGEE+             (BOHR+BERN)
BINON    69 PL 30B 510       DUTEIL,KACHANOV,KHROMOV,KUTYIN+              (SERP)

ANTIPOV1 71 PL 34B 164       +DENISOV,DONSKOV,GORIN,KACHANOV+             (SERP)
ANTIPOV2 71 NP B31 235       +DENISOV,DONSKOV,GORIN,KACHANOV+             (SERP)
DARDO    72 NC 9A 319        DARDO,NAVARRA,PENENGO,SITTE                  (TCRI)
TONWAR   72 JPA 5 569        TONWAR,NARANAN,SREEKANTAN                    (TATA)
ALPER    73 PL 46B 265        (CERN+LIVP+LUND+BOHR+RHEL+STCH+BERG+LCUC)
LEIPUNER 73 PRL 31 1226      +LARSEN,SESSOMS,SMITH,WILLIAMS+         (BNL+YALE)

APPEL    74 PRL 32 428       +BOURQUIN,GAINES,LEDERMAN,PAAR+         (COLU+FNAL)
FRANKEL  74 PR D9 1932       +FRATI,RESVANIS,YANG,NEZRICK            (PENN+FNAL)
YOCK     74 NP B76 175       P.C.M.YOCK                       (UNIV OF AUCKLAND)

ALBROW   75 NP B97 189       +BARBER,BENZ+(CERN+DARE+FOM+LANC+MCHS+UTRE)
APEL     75 PL 56B 190       +AUGENSTEIN,BERTOLUCCI,DONSKOV,+(SERP+CERN)
BOYARSKI 75 PRL 34 762       +BREIDENBACH,BULOS,FELDMAN+              (SLAC+LBL)
BLAGOV   75 YAD.FIZ. 21,300  +KOMAR,MURASHOVA,SYREISHCHIKOVA+             (LEBD)
FRANKEL  75 PR D12 2561      +FRATI,RESVANIS,YANG,NEZRICK            (PENN+FNAL)
JOVANOVI 75 PL 56B 105       JOVANOVICH+ (MANI+AACH+CERN+GENO+HARV+TORI)
YOCK     75 NP B86 216       P.C.M. YOCK               (UNIV OF AUCKLAND+SLAC)

ALEKSEE1 76 SJNP 22 531      ALEKSEEV,ZAITSEV,KALININA,KRUGLOV+           (JINR)
ALEKSEE2 76 SJNP 23 633      ALEKSEEV,ZAITSEV,KALININA,KRUGLOV+           (JINR)
BACCI    76 PL 56B 190       +BIDOLI,PENSO,STELLA,+                  (ROMA+FRAS)

BALDIN   76 SJNP 22 264      +VERTOGRADOV,VISHNEVSKII,GRISHKEVICH+(JINR)
BARBIELL 76 PL 64B 359       BARBIELLINI,NICOLETTI+(FRAS+NAPL+PISA+ROMA)
BRIATORE 76 NC 31A 553       +DARDO,PIAZZOLI,MANNOCCHI+ (LCGT+FRAS+FREI)
EARTLY   76 PRL 36 1355      +GIACOMELLI,PRETZL              (FNAL+BGNA+MPIM)
ESPOSITO 76 PL 64B 362       +FELICETTI,MARINI,+     (FRAS+ROMA+PADO+NAPL)
GUSTAFSO 76 PRL 37 474       GUSTAFSON,AYRE,JONES,LONGO,MURTHY            (MICH)

HOM1     76 PRL 36 1236      +LEDERMAN,PARR,SNYDER+          (COLU+FNAL+STON)
HOM2     76 PRL 37 1374      +LEDERMAN,PAAR,SNYDER,+         (COLU+FNAL+STON)
THEODOSI 76 PRL 37 126       THEODOSIOU,GITTELMAN,HANSON,LARSON+          (CCRN)

ASCHMAN  77 PRL 39 124       +COYNE,GROOM+         (PRIN+PAVI+UMD+UCSD+SLAC)
BARISH2  77 PRL 38 577       +BARTLETT,BODEK,BROWN +          (CIT+FNAL+ROCK)
BENVENUT 77 PRL 38 1110      BENVENUTI,CLINE+ (FNAL+HARV+PENN+RUTG+WISC)
BLETZACK 77 PRL 38 1241      BLETZACKER,NIEH,SONI                    (STON+UCSB)
BENSINGE 77 NP B119 77        (BRAN+BNL+CARN+CINC+CUNY+MASA+PENN+SMAS +)

CHANG    77 PRL 39 519       +CHEN,VAN GINNEKEN                      (MSU+FNAL)
HOLDER   77 PL 70B 393       +KNOBLOCH,MAY+     (CERN+DORT+HEID+SACL+BGNA)

ALBRIGHT 78 PR D18 108       +SMITH,VERMASEREN               (FNAL+STON+PURD)
ALIBRAN  78 PL 74B 134       AACH+BARI+BERG+BRUX+CERN+EPOL+MILA+ORSA+
ASRATYAN 78 PL 79B 497       +EPSTEIN,FAKHRUTDINOV+                  (ITEP+SERP)
BELLOTTI 78 PL 76B 223       +FIORINI,ZANOTTI                             (MILA)
BENVENUT 78 PRL 40 488       BENVENUTI+          (FNAL+HARV+PENN+RUTG+WISC)
BHAT     78 PRAM 10 115      +RAMANA MURTY                                (TATA)
BOSETTI  78 PL 74B 143       +DEDEN+            (AACH+BONN+CERN+LOIC+OXF+SACL)

CARROLL  78 PRL 41 777       +CHIANG,JOHNSON,KYCIA,KI +              (BNL+PRIN)
CUTTS    78 PRL 41 363       +DULUDE +          (BROW+FNAL+ILL+BARI+MIT+WARS)
DONNELLY 78 PR D18 1607      +FREEDMAN,LYTEL,PECCEI,SCHWARTZ              (STAN)
    ALSO 76 PRL 37 315       REINES,GURR,SOBEL
    ALSO 74 PRL 33 179       GURR,REINES,SOBEL
HANSL1   78 PL 74B 139       +HOLDER,KNOBLOCH+(CERN+DORT+HEID+SACL+BGNA)
HANSL2   78 PL 77B 114       +HOLDER,KNOBLOCH+(CERN+DORT+HEID+SACL+BGNA)
    ALSO 78 NP B142 381      HANSL,HOLDER+      (CERN+DORT+HEID+SACL+BGNA)

HOLDER   78 PL 73B 105       +KNOBLOCH,MAY+     (CERN+DORT+HEID+SACL+BGNA)
LOVELESS 78 PL 78B 505       +BENADA+CAMERINI+ (WISC+LBL+FNAL+HAWA+WASH)
MICELMAC 78 LNC 21 441       MICELMACHER,PONTECORVO                       (JINR)
MORI     78 PRL 40 432       +BENVENUTI+         (FNAL+HARV+PENN+RUTG+WISC)
VIDAL    78 PL 77B 344       +HERB,LEDERMAN,SNYDER+ (COLU+FNAL+STON+UCB)
VIERTEL  78 LNC 22 235       +HAHN,SCHACHER                               (BERN)
VYSOTSSK 78 JETPL 27 502     VYSOTSSKII+(INST.APPL.MATH.,USSR ACA. SCI.)

ARMITAGE 79 NP B150 87       +BENZ,BOBBINK+ (CERN+DARE+FOM+MCHS+UTRECHT)
BENVENUT 79 PRL 42 1024      BENVENUTI+    (FNAL+HARV+OSU+PENN+RUTG+WISC)
BOZZOLI  79 NP B159 363      +BUSSIERE,GIACOMELLI    (BGNA+CERN+LAPP+SACL)

COTEUS   79 PRL 42 1438      +DIESBURG,FINE,LEE,SOKOLSKY+ (COLU+ILL+BNL)
DEGROOT  79 PL 85B 131       +HANSL,HOLDER+     (CERN+DORT+HEID+SACL+BGNA)
DISHAW   79 PL 85B 142       +DIAMANT-BERGER,FAESSLER,LIU+           (SLAC+CIT)
GOODMAN  79 PR D19 2572      +ELLSWORTH,ITO,MACFALL,SIOHAN +               (UMD)
SMITH    79 NP B149 525      +BENNETT                                     (RHEL)

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Data Card Listings

For notation, see key at front of Listings.

Mesons

$\pi^{\pm}$, π^0, η, $\rho(770)$

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S=0, C=0 MESON STATES

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$\pi^{\pm}$

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8  CHARGED PION(140,JPG=0--) I=1
   SEE STABLE PARTICLE DATA CARD LISTINGS
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π^0

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9  NEUTRAL PICN(135,JPG=0--) I=1
   SEE STABLE PARTICLE DATA CARD LISTINGS
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η

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14  ETA(549,JPG=0-+) I=0
    SEE STABLE PARTICLE DATA CARD LISTINGS
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$\rho(770)$

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9  RHO(770,JPG = 1-+) I=1
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Note on the ρ^0 Mass and Width

Because of the broadness of the ρ meson, determinations of the resonance parameters are beset with many difficulties. In physical-region fits, it is well known that the ρ line shape does not correspond to a relativistic Breit-Wigner function with a P-wave width, but requires one further shape parameter (PISUT 68). The same remark applies to the energy dependence of the phase shift δ_1^1. Different ways of introducing the shape parameter lead to systematic differences in addition to the systematic errors due to different ways of accounting for the background in physical-region fits, or due to different ways of projecting out the partial waves in phase-shift analyses.

We consider phase-shift analyses more reliable than physical-region fits.

All phase-shift analyses can now be summarized by two pairs of parameters which agree: in an analysis of the BATON 70, HYAMS 73, and PROTOPOPESCU 73 phase shifts, ROOS 75 obtains $M(\rho^0) = (776.3 \pm 0.4)$ MeV, $\Gamma(\rho^0) = (154.5 \pm 1.0)$ MeV; combining the HYAMS 73 data with more recent data on polarized protons, BECKER2 79 obtains $M(\rho^0) = (776.1 \pm 2.6)$ MeV, $\Gamma(\rho^0) = (161.8\,^{+7.6}_{-7.2})$ MeV. We base our "educated guess" on these values.

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                         9  RHO MASS (MEV)

M       WE NO LONGER LIST S-WAVE BREIT-WIGNER FITS, PBAR P DATA WITH HIGH
M       COMBINATORIAL BACKGROUND, AND INSIGNIFICANT OR DOUBTFUL DATA.
M       SEE ALSO THE MINI-REVIEW ABOVE.

M   MIXED CHARGES
M      240 (752.0)                           ALITTI    63 HBC   -0 1.6 PI-P
M      290 (755.0)                           CHADWICK  63 HBC   +-0 0.0 PBAR P

M    CHARGED ONLY
M              (748.0)                       KENNEY     62 HBC   -  1.2 PI-P
M          130 (775.0)                       GUIRAGOSS  63 HBC   -  3.3 PI-P
M     R        (760.0)   (9.0)               CARMONY    64 HBC   +  3.5 PI+P,TCUT 4
M     R        (768.0)   (5.0)               BLIEDEN    65 MMSP  -  3-5 PI- P          6/66
M     R        (765.0)   (5.0)               ALFF-STEI  66 HBC   +  2-3 PI+ P          6/66
M     R        (760.0)   (5.0)               HAGOPIAN1  66 HBC   -  3.0 PI- P          6/66
M     R        (765.0)   (5.0)               HAGOPIAN2  66 HBC   -  2.14 PI-,TCUT12    9/67
M     R   2775 (753.5)  (10.5)               JACOBS     66 HBC   -  2-3PI-,T CUT 20    6/68
M     R        (758.0)  (10.0)               JAMES      66 HBC   +  2.1 PI+,TCUT2.5    8/66
M     R        (749.0)   (3.0)               WEST       66 HBC   -  2.1 PI- P         10/66
M    Z     900  767.      6.                 EISNER     67 HBC   -  4.2 PI-,T CUT10    1/73
M     R        (768.0)   (5.0)               MILLER     67 HBC   -  2.7 PI-,T CUT20    9/66
M     R        (773.0)   (2.0)               BATON      68 HBC   -  2.8 PI-,T CUT13    7/69
M         1700 (782.)    (5.)                FOSTER     68 HBC   +- PBAR P AT REST     1/73
M         9650  764.3     1.9      1.8       PISUT      68 RVUE  -  1.7-3.2PI-,CT10    6/68
M     A   9650 (764.3)  (19.2)    (3.3)      PISUT      68 RVUE  -  1.7-3.2PI-,CT10    6/68
M         1300  778.0     4.0                REYNOLDS   69 HBC   -  2.26 PI- P        12/78*
M    X    6500  766.      7.                 BYERLY     73 OSPK  -  5. PI- P           2/74
M               . . . . . . . . .
M    AVG        766.7     2.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
M    STUDENT    766.0     2.0     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                          (SEE IDEOGRAM BELOW )
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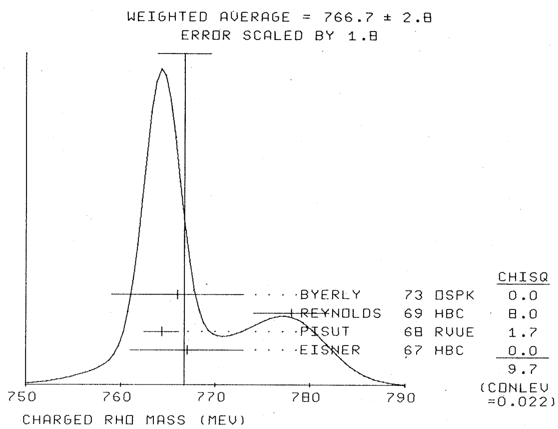


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MO   NEUTRAL ONLY
MO        190 (750.0)   (20.0)               SAMIOS     62 HBC   0 4.7 PI-P
MO   R    300 (760.0)   (10.0)               ABOLINS    63 HBC   0 3.5 PI+P
MO        160 (775.0)                        GUIRAGOSS  63 HBC   0 3.3 PI-P
MO   R    500 (770.0)   (10.0)               GOLDHABER  64 HBC   0 3.7 PI+P
MO   R        (750.0)    (5.0)               ALFF-STEI  66 HBC   0 2-3 PI+ P          6/66
MO   R        (775.0)    (5.0)               HAGOPIAN1  66 HBC   0 3.0 PI- P          6/66
MO   R        (770.)     (5.)                HAGOPIAN2  66 HBC   0 2.1 PI-,TCUT 12    2/67
MO   R   4207 (758.0)    (7.5)               JACOBS     66 HBC   0 2-3PI-,T CUT 20    6/68
MO   R        (765.0)    (8.0)               JAMES      66 HBC   0 2.1 PI+ P          6/66
MO   R        (760.0)    (3.0)               WEST       66 HBC   0 2.1 PI- P         10/66
MO   P   4000 (765.)     (5.0)               ASBURY 2   67 CNTR  0 GAMMA + PB         1/73
MO   R        (768.0)    (2.0)               BACCN      67 HBC   0 1.7 PI-P           9/67
MO   R        (761.)     (3.)                HUWE       67 HBC   0 2.4 PI- P          7/67
MO   R        (770.0)    (4.0)               MILLER     67 HBC   0 2.7 PI-,T CUT20    9/66
MO   R        (775.0)    (2.0)               ARMENISE   68 DBC   0 5.1 PI+D           6/68
MO       1900 (776.)     (5.)                FOSTER     68 HBC   0 PBAR P AT REST     1/73
MO       2250  775.0      3.0                HYAMS      68 OSPK  0  11.2 PI- P      . 9/68
MO      13300  766.7      2.8                PISUT      68 RVUE  0 1.7-3.2PI-,CT10    1/73
MO   B        (754.0)    (9.0)               AUSLENDER  69 OSPK  0 E+E- COLL.BEAMS    2/74
MO   R        (768.4)    (2.4)               MALAMUD    69 RVUE  0 2-4 PI-P           1/73
MO       1700  774.0      3.0                REYNOLDS   69 HBC   0 2.26 PI- P        12/78*
MO C           759.0      7.0                SCHAREN    69 HBC   0 2-4 PI- P          1/73
MO   P        (765.0)   (10.0)               ALVENSLEB  70 CNTR  0 GAMMA A,TCUT.01    1/73
MO   C12630   (760.0)                        BATCN      70 HBC   0 2.8 PI- P          1/71
MO       140K  767.7      1.9                BIGGS      70 CNTR  0 PHCTOPRCD.         1/73
MO C           761.0      5.0                BAILLCN    72 ASPK  0 15. PI- P          1/73
MO       1930  767.0      4.0                BALLAM     72 HBC   0 2.8 GAMMA P        1/73
MO       2430  770.0      4.0                BALLAM     72 HBC   0 4.7 GAMMA P        1/73
MO   B        (775.4)    (7.3)               BENAKSAS   72 OSPK  0 E+E- COLL.BEAMS    2/74
MO             772.3      5.9                BENAKSAS   72 RVUE  0 E+E- COLL.BEAMS    2/74
MO Z 11200     773.5      1.7                JACOBS     72 HBC   0 2.8 PI- P          1/73
MO       6800  764.0      3.0                RATCLIFF   72 ASPK  0 15. PI-P,TCJT.3.   2/74
MO   P        (775.)     (5.)                GLADDING   73 CNTR  0 2.9-4.7 GAMMA P    2/74
MO   H        (778.)     (2.)                HYAMS      73 ASPK  0 17.PI-P,PI+PI-N    1/74
MO C 32000     775.0      4.0                PROTOPOPE  73 HBC   0 7.1 PI+P,TCUT.4    2/74
MO       4100  767.       4.                 ENGLER     74 DBC   0 6. PI+N,PI+PI-P   12/75
MO   H        (770.)     (9.)                ESTABROOK  74 RVUE  0 17 PI-P,PI+PI-N   12/75
MO   G        (771.)     (1.)                GRAYER     74 ASPK  0 17.PI-P,PI+PI-N    2/74
MO   D        (776.3)    (0.4)               ROOS       75 RVUE  0 PHASE SHIFTS      12/75
MO      76000  768.0      1.0                DEUTSCHMA  76 HBC   0 16. PI+ P          4/78*
MO             767.6      2.7                BARTALUCC  78 CNTR  0 BREMS,E+E-P       12/77
MO X           769.0      3.0                WICKLUND   78 ASPK  0 3,4,6 PI+-PN       4/78*
MO             776.1      2.6                BECKER     79 ASPK  0 17.PI-P PCLARIZ   12/79*
MO              . . . . . . . . .
MO   AVG       769.42     0.86    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
MO   STUDENT   769.11     0.78    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                          (SEE IDEOGRAM BELCW )

M          ----------NOTES----------

M    A    ERRORS ARE 2 STD AND INCLUDE SYSTEMATIC UNCERTAINTIES FROM THEORY
M    B    INCLUDED IN BENAKSAS 72 REVUE VALUE
M    C    FROM POLE EXTRAPOLATICN
M    D    INCLUDES BATON 70,HYAMS 73,PROTOPOPESCU 73
M    G    INCLUDED IN BECKER 79 ANALYSIS
M    H    FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
M    P    FROM PHOTOPRODUCTICN, MODEL DEPENDENT.
M    R    INCLUDED IN PISUT 68 RVUE
M    X    SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
M    Z    MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K* TYPED NOTE
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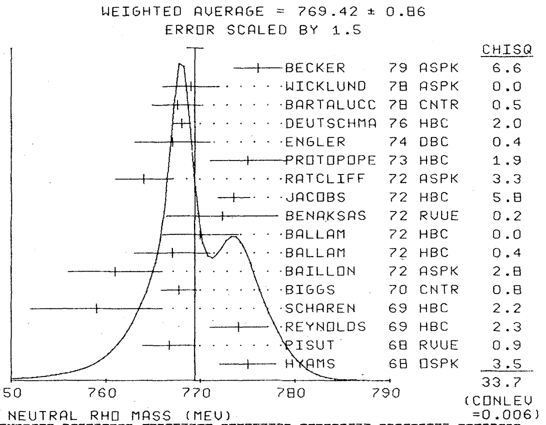
Mesons
$\rho(770)$

Data Card Listings
For notation, see key at front of Listings.

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                 9   (RHO0) - (RHO+-) MASS DIFFERENCE (MEV)

D  A  3600   -5.      5.               FOSTER    68 HBC  +-0 PBAR P AT REST   12/78*
D    22950    2.4     2.1              PISUT     68 RVUE     PI N TO RHO N     6/68
D  A  3000   -4.0     4.0              REYNOLDS  69 HBC   -0 2.26 PI- P       12/78*
D             . . . . . . . . . .
D   AVG       0.3     2.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
D   STUDENT   0.3     2.1      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

D  A    FROM QUOTED MASSES OF CHARGED AND NEUTRAL MODES
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                 9   RHO WIDTH (MEV)

W       WE NO LONGER LIST S-WAVE BREIT-WIGNER FITS, PBAR P DATA WITH HIGH
W       COMBINATORIAL BACKGROUND, AND INSIGNIFICANT OR DOUBTFUL DATA.
W       SEE FURTHER MINI-REVIEW ABOVE.

W   MIXED CHARGES
W      290 (110.0)                         CHADWICK  63 HBC  +-0 0.0 PBAR P

W   CHARGED ONLY
W      130 (125.0)                         GUIRAGOSS 63 HBC   -  3.3 PI-P
W          (90.0)    (10.0)                SACLAY    63 HBC   +  2.8 PI+P
W       98 (180.0)                         BONDAR    64 HBC   -  4.1 PI-P
W   R       (77.0)   (20.0)                CARMONY   64 HBC   +  3.5 PI+P,TCUT 4
W   R      (100.0)                         ALFF-STEI 66 HBC   +  2-3 PI+ P        6/66
W   R      (127.0)    (5.0)                BLIEDEN   66 MMSP  -  3-5 PI- P        6/66
W   R      (150.0)   (20.0)                HAGOPIAN1 66 HBC   -  3.0 PI- P        6/66
W   R      (135.0)   (20.0)                HAGOPIAN2 66 HBC   -  2.14 PI-,TCUT12  9/67
W   R 2775 (137.1)   (20.0)                JACOBS    66 HBC   -  2-3PI-,T CUT 20  6/68
W   R      (147.0)   (19.0)                JAMES     66 HBC   +  2.1 PI+,TCUT2.5  8/66
W   R      (149.0)    (13.0)               WEST      66 HBC   -  2.1 PI- P       10/66
W      900  146.      13.                  EISNER    67 HBC   -  4.2 PI-,T CUT10  9/67
W   R      (153.0)   (13.0)                MILLER    67 HBC   -  2.7 PI-,T CUT20  9/66
W   R      (150.0)    (5.0)                BATON     68 HBC   -  2.8 PI- P        7/69
W     1700 (145.0)   (10.0)                FOSTER    68 HBC  +-  PBAR P AT REST   1/73
W     9650  147.3     4.0       3.9        PISUT     68 RVUE  -  1.7-3.2PI-,CT10  6/68
W     1300  157.0    10.0                  REYNOLDS  69 HBC   -  2.26 PI- P      12/78*
W   X 6500  146.     12.                   BYERLY    73 OSPK  -  5. PI- P         2/74
W           . . . . . . . . . . .
W   AVG     148.2     3.4      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W   STUDENT 148.2     3.7      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

WO  NEUTRAL ONLY
WO     190 (150.0)   (20.0)                SAMIOS    62 HBC    0 4.7 PI-P
WO  R  300  (90.0)   (10.0)                ABOLINS   63 HBC    0 3.5 PI+P
WO     160 (175.0)                         GUIRAGOSS 63 HBC    0 3.3 PI-P
WO  R  500 (130.0)                         GOLDHABER 64 HBC    0 3.7 PI+P
WO  R      (100.0)                         ALFF-STEI 66 HBC    0 2-3 PI+ P        6/66
WO  R      (120.0)   (10.0)                HAGOPIAN1 66 HBC    0 3.0 PI- P        6/66
WO  R      (135.0)   (20.0)                HAGOPIAN2 66 HBC    0 2.14 PI-P,LOW T  9/67
WO  R 4207 (122.2)   (15.0)                JACOBS    66 HBC    0 2-3PI-,T CUT 20  6/68
WO  R      (103.0)   (13.0)                JAMES     66 HBC    0 2.1 PI+ P        6/66
WO  R      (173.0)   (13.0)                WEST      66 HBC    0 2.1 PI- P       10/66
WO  P 4000 (130.)     (5.)                 ASBURY 2  67 CNTR   0 GAMMA + PB       1/73
WO  R      (148.0)    (8.0)                BACON     67 HBC    0 1.7 PI-P         9/67
WO  R      (152.)    (15.)                 HUWE      67 HBC    0 2.4 PI- P        7/67
WO  R      (160.0)   (15.0)                MILLER    67 HBC    0 2.7 PI-,T CUT20  9/66
WO  R      (167.0)    (6.0)                ARMENISE  68 DBC    0 5.1 PI+D         6/68
WO    1900 (132.)    (10.)                 FOSTER    68 HBC    0 PBAR P AT REST   1/73
WO Z  2250  145.0    12.0                  HYAMS     68 OSPK   0 11.2 PI- P     . 1/73
WO  P      (160.0)   (10.0)                LANZEROTT 68 CNTR   0 GAMMA P          1/73
WO  B      (105.0)   (20.0)                AUSLENDER 69 OSPK   0 E+E- COLL.BEAMS  2/74
WO  R      (132.0)   (13.0)                MALAMUD   69 RVUE   0 2-4 PI-P         1/73
WO     1700 143.0     8.0                  REYNOLDS  69 HBC    0 2.26 PI- P      12/78*
WO C        119.0    20.0                  SCHAREN   69 HBC    0 2-4 PI- P        1/73
WO  P      (140.0)    (5.0)                ALVENSLEB 70 CNTR   0 GAMMA A,TCUT.01  1/73
WO  C12630 (131.0)                         BATON     70 HBC    0 2.8 PI- P        1/71
WO    140K  146.1     2.9                  BIGGS     70 CNTR   0 PHOTOPROD.       1/73
WO C        108.0    20.0                  BAILLON   72 ASPK   0 15. PI- P        1/73
WO Z  2430  155.0    12.0                  BALLAM    72 HBC    0 4.7 GAMMA P      1/73
WO Z  1930  145.0    13.0                  BALLAM    72 HBC    0 2.8 GAMMA P      1/73
WO  B      (149.6)   (23.2)                BENAKSAS  72 OSPK   0 E+E- COLL.BEAMS  2/74
WO          135.8    15.1                  BENAKSAS  72 RVUE   0 E+E- COLL.BEAMS  2/74
WO   11200 (178.35)   (2.5)                JACOBS    72 HBC    0 2.8 PI- P        1/73
WO    6800  157.0     8.0                  RATCLIFF  72 ASPK   0 15. PI-P,TCUT.3. 2/74
WO  P      (147.)    (11.)                 GLADDING  73 CNTR   0 BREMS.           2/74
WO  H      (152.)     (2.)                 HYAMS     73 ASPK   0 17.PI-P,PI+PI-N  1/74
WO C 32000  160.0    10.0                  PROTOPOPE 73 HBC    0 7.1 PI+P,TCUT.4  2/74
WO    4100  146.     14.                   ENGLER    74 DBC    0 6. PI+N,PI+PI-P 12/75
WO  H      (143.)    (13.)                 ESTABROOK 74 RVUE   0 17 PI-P,PI+PI-N 12/75
WO  G      (161.)     (4.)                 GRAYER    74 ASPK   0 17.PI-P,PI+PI-N  2/74
WO  D      (154.5)    (1.0)                ROOS      75 RVUE   0 PHASE SHIFTS    12/75
WO   76000  154.0     2.0                  DEUTSCHMA 76 HBC    0 16. PI+ P        4/78*
WO          150.9     3.0                  BARTALUCC 78 CNTR   0 BREMS,E+E-P     12/77
WO X        152.0     9.0                  WICKLUND  78 ASPK  0 3,4,6 PI+-PN      4/78*
WO          161.8     7.6       7.2        BECKER    79 ASPK   0 17.PI-P POLARIZ 12/79*
WO          . . . . . . . . . . .
WO  AVG     151.2     1.3      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
WO  STUDENT 151.3     1.6      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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W          -----------NOTES-----------

W   B    INCLUDED IN BENAKSAS 72 REVUE VALUE
W   C    FROM POLE EXTRAPOLATION
W   D    INCLUDES BATON 70,HYAMS 73,PROTOPOPESCU 73
W   G    INCLUDED IN BECKER 79 ANALYSIS
W   H    FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
W   P    FROM PHOTOPRODUCTION, MODEL DEPENDENT.
W   R    INCLUDED IN PISUT 68 RVUE
W  X     SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
W  Z     WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE
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                 9   RHO PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      RHO INTO 2PI                                     139+ 139
P2      RHO INTO 4PI                                     139+ 139+ 139+ 139
P3      RHO INTO PI GAMMA                                139+   0
P4      RHO INTO E+ E-                                    .5+  .5
P5      RHO INTO PI ETA (VIOLATES G)                     139+ 548
P6      RHO INTO MU+ MU-                                 105+ 105
P7      RHO INTO PI+ PI- PIO (VIOLATES G)                139+ 139+ 134
P8      RHO INTO ETA GAMMA                               548+   0
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                 9   RHO BRANCHING RATIOS

R1      RHO INTO 4PI/2PI                                 (P2)/(P1)

R1      RHO+- INTO (PI+- PI+ PI- PIO) / (PI+- PIO)
R1            (0.026)OR LESS          BLIEDEN   66 MMSP  -  3-5 PI- P          6/66
R1            (0.01) OR LESS          DEUTSCHMA 66 HBC   +   8.0 PI+ P         6/66
R1            (0.002)OR LESS          FERBEL    66 HBC   +- PI+- P ABOVE 2.5  10/66
R1             0.0035    0.004        JAMES     66 HBC   +   2.1 PI+P         11/66

R1      RHO0 INTO (PI+ PI- PI+ PI-) / (PI+ PI-)
R1            (0.008)OR LESS          JAMES     66 HBC    0 2.1 PI+P           6/66
R1            (0.002)OR LESS          CHUNG     68 HBC    0 3.2,4.2 PI-P       7/67
R1            (0.002)OR LESS  CL=.90  HUSCN     68 HLBC   0 16.0 PI- P         1/71
R1            (0.0015)OR LESS CL=.90  GERMAN CO 69 HBC    0 2.5-5.8 GAMMA P   10/67

R2      RHO INTO PI GAMMA/2PI   (UNITS 10**-3)           (P3)/(P1)
R2   M        (20.)    OR LESS        LANZEROTT 65 CNTR     GAMMA P(BREMS)    11/66
R2            (5.)     OR LESS CL=.97 FIDECARO  66 OSPK  -                    10/66
R2            (7.)     OR LESS        HUSON     66 HLBC  -  15 PI-PB           6/66
R2   M        (2.)     OR LESS CL=.90 GERMAN CO 69 HBC
R2    C        0.24      0.07         GOBBI     74 OSPK  - 23. PI-A,PI-PIOA  12/75
R2    C  GOBBI 74 QUOTES THE PARTIAL WIDTH FOR RHO- INTO PI- GAMMA
R2    C  AS (35 +- 10) KEV
R2   M          ONE PION EXCHANGE MODEL USED IN THIS ESTIMATION
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Note on the e^+e^- and $\mu^+\mu^-$ Decays

Extraction of a ratio for $\rho^0 \to e^+e^-$ is complicated by interference with ω decay. In photoproduction, $\gamma A \to e^+e^-A$, there is substantial interference between the allowed $(\rho^0,\omega) \to e^+e^-$ decays. The interference in the colliding-beam reaction $e^+e^- \to \pi^+\pi^-$ is due to G-parity-violating mixing of the overlapping ρ^0 and ω resonances; it alters the results for the rate $\Gamma(\rho^0 \to e^+e^-)$ only by a small amount. Therefore at present we average only the values from the $e^+e^- \to \pi^+\pi^-$ experiments.

The same comment applies to the decay $\rho^0 \to \mu^+\mu^-$.

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R3      RHO INTO(E+ E-)/(PI+PI-) (UNITS 10**-4)              (P4)/(P1)
R3
R3       SEE MINI-REVIEW ABOVE.
R3
R3   P    94   (0.65)    (0.14)            ASBURY 1  67 CNTR     PHOTOPRODUCTION  9/67
R3   H         (0.65)    (1.1)     (0.5)   HERTZBACH 67 OSPK ASSUME SU(3)+MIXING.10/66
R3   A    33   (0.53)    (0.11)            ASTVACATU 68 OSPK ASSUME SU(3)+MIXING  6/68
R3              0.50      0.10             AUSLENDER 69 OSPK    E+E- COLLID.BEAM  9/68
R3   F         (0.49)    (0.12)    (0.15)  BIGGS     70 CNTR    PHOTOPRODUCTION   6/70
R3              0.41      0.05             BENAKSAS  72 OSPK     E+E- COLL.BEAMS 12/72
R3           . . . . . . . . .
R3   AVG        0.428     0.045    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3   STUDENT    0.428     0.049    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R3   A          NOT SEPARATED FROM OMEGA DECAY. ERROR STATISTICAL ONLY.
R3   F          ASSUMING RHO WIDTH 140 MEV. ERROR STATISTICAL ONLY.
R3   H          NOT SEPARATED FROM OMEGA DECAY.
R3   P          POSSIBLY LARGE RHO-OMEGA INTERFERENCE

R4      RHO INTO (PI ETA)/(2PI)                               (P5)/(P1)
R4             (0.03) OR LESS              DEUTSCHMA 66 HBC  +     8.0 PI+ P      6/66
R4             (0.008)OR LESS              FERBEL    66 HBC  +- PI+- P ABOVE 2.5 11/66

R5      RHO INTO (MU+ MU-)/(PI+ PI-) (UNITS 10**-4)          (P6)/(P1)
R5
R5       SEE MINI-REVIEW ABOVE.
R5
R5    H         0.97      0.31      0.33   HYAMS     67 OSPK    11 PI- LI H       6/67
R5    R         0.82      0.16      0.36   ROTHWELL  69 CNTR   PHOTOPRODUCTION    4/70
R5    W         0.56      0.15             WEHMANN   69 OSPK     12 PI- ON C,FE   7/69
R5           . . . . . . . . .
R5   AVG        0.67      0.12     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5   STUDENT    0.67      0.14     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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Data Card Listings

For notation, see key at front of Listings.

Mesons

ρ(770), ω(783)

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R5   H        HYAMS MASS RESOL. IS 20 MEV. THE OMEGA REGION WAS EXCLUDED.  .
R5   R        POSSIBLY LARGE RHO-OMEGA INTERFERENCE LEADS US TO INCREASE
R5   R        THE MINUS ERROR
R5   W        RESULT CONTAINS (11 +- 11) PER CENT CORRECTION USING SU(3)
R5   W        FOR CENTRAL VALUE. THE ERROR ON THE CORRECTION TAKES ACCOUNT
R5   W        OF POSSIBLE RHO-OMEGA INTERFERENCE AND THE UPPER LIMIT AGREES
R5   W        WITH THE UPPER LIMIT OF (OMEGA INTO MU+ MU-) FROM THIS EXPT.

R6      RHO  INTO (PI+ PI- PIO)/(PI+ PI-)                (P7)/(P1)
R6   G        (0.01) OR LESS  CL=.84   ABRAMS    71 HBC    0 3.7 PI+ P       11/71
R6   G      MCDEL DEPENDENT,ASSUMES I = 1,2,OR 3 FOR THE 3PI SYSTEM          11/71

R7      RHO INTO (ETA GAMMA)/TOTAL (UNITS 10**-4)        (P8)
R7   A        (3.6)    (0.9)           ANDREWS   77 CNTR  0 6.7-10 GAMMA CU  12/77
R7   B        (5.4)    (1.1)           ANDREWS   77 CNTR  0 6.7-10 GAMMA CU  12/77
R7   A   SOLUTION CORRESPONDING TO CONSTRUCTIVE OMEGA-RHO INTERFERENCE
R7   A   THE QUARK MODEL PREDICTS A RELATIVE DECAY PHASE OF ZERO.
R7   B   SOLUTION CORRESPONDING TO DESTRUCTIVE OMEGA-RHO INTERFERENCE

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REFERENCES FOR RHO


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ANDERSON 61 PRL 6 365          ANDERSON,BANG,BURKE,CARMONY,SCHMITZ   (LRL)
ERWIN    61 PRL 6 628          A.R.,R.MARCH,W.D.WALKER,E.WEST        (WISC)
KENNEY   62 PR 126 736         V P KENNEY,W D SHEPHARD,C D GALL (KENTUCKY)
SAMIOS   62 PRL 9 139          SAMIOS,BACHMAN,LEA+    (BNL+CUNY+COLU+KNTY)
XUCNG    62 PR 128 1849        NGUYEN HUU XUONG,GERALD R LYNCH        (LRL)

ABCLINS  63 PRL 11 381         ABOLINS,LANDER,MEHLHOP,NGUYEN,YAGER   (UCSD)
ALITTI   63 NC 29 515          ALITTI,BATCN,ARMENISE+(SACL+ORSA+BARI+BGNA)
CHADWICK 63 PRL 10 62          CHADWICK,DAVIES,DERRICK,CRESTI + (OXF+PADO)
GUIRAGOS 63 PRL 11 85          ZAVEN GUIRAGOSSIAN                     (LRL)
SACLAY   63 SIENA CONF 1 239   SACLAY+ORSAY+BARI + BOLCGNA- COLLABORATION

BONDAR   64 NC 31 729          BONDAR+    (AACHEN+BIRM+BONN+DESY+LOIC+MPIM)
CARMONY  64 DUBNA CONF 1 486   CARMONY,HOA,LANDER,NG.H.XUONG,YAGER   (UCSD)
GOLDHABE 64 PRL 12 336         GOLDHABER, BROWN, KADYK, SHEN+     (LRL+UCB)

ALYEA    65 PL 15 82           ALYEA,CRITTENDEN,MARTIN,RHODE +    (INDIANA)
ARMENISE 65 NC 37 361          SACLAY+ORSAY+BARI+BOLOGNA     COLLABORATION
BLIEDEN  65 PL 19 444          CERN MISSING MASS SPECTROMETER GROUP (CERN)
CLARK    65 PR 139 B 1556      A CLARK,CHRISTENSON,CRONIN,TURLAY(PRINCETO)
GUTAY    65 NC 39 381          GUTAY,LANNUTTI,TULI                    (FSU)
LANZEROT 65 PRL 15 210         LANZEROTTI,BLUMENTHAL,EHN,FAISSLER + (HARV)
ZDANIS   65 PRL 14 721         ZDANIS,MADANSKY,KRAEMER +          (JHU+BNL)

ACCENSI  66 PL 20 557          ACCENSI,ALLES-BORELLI,FRENCH,FRISK+   (CERN)
ALFF-STE 66 PR 145 1072        ALFF-STEINBERGER,BERLEY,BRUGGER+(COLU+RUTG)
BALTAY   66 PR 145 1103        +FRANZINI,LUTJENS,SEVERINS,TYCKO+(COLUMBIA)
BLIEDEN  66 NC 43 71           CERN MISSING MASS SPECTROMETER GROUP (CERN)
CAMBRIDG 66 PR  146   994      CAMBRIDGE BUBBLE CHAMBER GROUP  (MIT+HARV+)
CASON    66 PR  148  1282      N M CASON                        (WISCONSIN)
DEUTSCHM 66 PL 20 82           DEUTSCHMANN,STEINBERG + (AACH+BERLIN+ CERN)
FERBEL   66 PL 21 111          FERBEL                           (ROCHESTER)
FIDECARO 66 PL   23   163      G+M FIDECARO,J POIRIER,P SCHIAVCN     (CERN)
HAGOPIAN166 PR 145 1128        HAGOPIAN,SELOVE,ALITTI, BATON+ (PENN+SACLAY)
HAGOPIAN266 PR  152  1183      HAGOPIAN,PAN    (PENNSYLVANIA,LRL-BERKELEY)
HUSON    66 PL 20 91           HUSON,ALLARD,DRIJARD,HENNESSY+ (ORSAY+EPOL)
JACOBS   66 UCRL-16877         L.D.JACOBS                             (LRL)
JAMES    66 PR 142 896         F E JAMES,KRAYBILL         (YALE+BROOKHAVEN)
WEST     66 PR 149 1089        WEST,BOYD,ERWIN,WALKER           (WISCONSIN)

ALLES-BO 67 NC 50 A 776        ALLES-BORELLI, FRENCH, FRISK,+    (CERN+BCNN)
ASBURY 1 67 PRL 19 869         +BECKER+BERTRAM+JOCS+JORDAN+      (DESY+CCLU)
ASBURY 2 67 PRL 19 865         +BECKER+BERTRAM+JOOS+JORDAN+      (DESY+COLU)
BACON    67 PR 157 1263        +FICKINGER,HILL,HOPKINS,ROBINSON+      (BNL)
BANNER   67 PL   25 B  300     +FAYOUX,HAMEL,ZSEMBERY,CHEZE+ (SACLAY+CAEN)
BARLOW   67 NC 50A 701         +LILLESTOL+MONTANET+  (CERN+CDEF+IRAD+LIVP)
BATON    67 PL 25 B 419        J.BATON,G.LAURENS,J.REIGNIER        (SACLAY)
    ALSO 67 NP B 3  349        J.BATON,G.LAURENS,J.REIGNIER        (SACLAY)
CLEAR    67 NC 49A 399         +JOHNSTON+COOPER+MANNER+     (TNTO+ANL+WISC)
DANYSZ   67 NC 51 A 801        DANYSZ+FRENCH+SIMAK                   (CERN)
EISNER   67 PR 164 1699        +JOHNSCN+KLEIN+PETERS+SAHNI+YEN+    (PURDUE)
FRENCH   67 NC 52A 442         +KINSCN+MCDCNALD+RIDDIFCRD+      (CERN+BIRM)
HERTZBAC 67 PR 155   1461      HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
    ALSO 65 ZDANIS
HUWE     67 PL 24B 252         +MARQUIT+OPPENHEIMER+SCHULTZ+WILSCN  (CCLU)
HYAMS    67 PL 24B 634         +KOCH+PELLETT+POTTER+VONLINDERN+(CERN+MPIM)
MILLER   67 PR 153 1423        MILLER,GUTAY,JOHNSCN,LOEFFLER +     (PURDUE)
POIRIER  67 PR 163 1462        +BISWAS,CASON,DERADO,KENNEY+     (NDAM+PENN)

ABC COLL 68 NP B4 501                   AACHEN+BERLIN+CERN CCLLABORATION*
ARMENISE 68 NC 54A 999         +GHIDINI,FORINO+      (BARI+BGNA+FIRZ+ORSAY)
ASTVACAT 68 PL 27 B  45        ASTVACATURCV,AZIMOV,BALDIN+   (JINR+MOSCOW)
BATON    68 PR 176 1574        J.P. BATCN, G. LAURENS              (SACLAY)
BLECHSCH 68 NC   53  A  1045   BLECHSCHMIDT,DOWD,ELSNER,+       (DESY+MCHS)
    ALSO 67 NC   52  A  1348
CHUNG    68 PR 165 1491        S.U.CHUNG,O.I.DAHL,J.KIRZ,D.H.MILLER  (LRL)
DONALD   68 NP B 6 174         +EDWARDS,FRODESEN,BETTINI+ (LIVP+OSLO+PADO)
FOSTER   68 NP B 6 107         +GAVILLET+LABROSSE+MONTANET+     (CERN+CDEF)
HUSON    68 PL 28B 208         +LUBATTI,SIX,VEILLET,+      (ORSA+MILA+UCLA)
HYAMS    68 NP B 7 1           +KOCH,POTTER,WILSON,VON LINDERN+(CERN+MPIM)
JONES    68 PR 166 1405        +BLEULER,CALDWELL,ELSNER,HARTING+     (CERN)
JOHNSON  68 PR 176 1651        +POIRIER,BISWAS, GUTAY+     (NDAM+PURD+SLAC)
KEY      68 PR 166 1430        +PRENTICE+COOPER+MANNER+     (TNTO+ANL+WISC)
LAMSA    68 PR 166 1395        +CASON+BISWAS+DERADO+GROVES+     (NOTREDAME)
LANZEROT 68 PR 166 1365        LANZEROTTI,BLUMENTHAL,EHN,FAISSLER + (HARV)
MARATECK 68 PRL 21 1613        +HAGOPIAN,+  (PENN+LRL+COLO+PURD+TNTO+WISC)
PISUT    68 NP B 6 325         J.PISUT,M.ROOS                        (CERN)

AUGUSTI1 69 PL 28 B 508        +BIZOT+BUON+HAISSINSKI+LALANNE+      (ORSAY)
AUGUSTI2 69 LNC 2 214          +LEFRANCOIS,LEHMANN,MARIN,+          (ORSAY)
AUSLENDE 69 SJNP 9  69         AUSLENDER,BUDKER,PANTUSCVA,PESTOV+   (NCVO)
GERMAN C 69 PR 188  2060       GERMAN BUBBLE CHAMBER COLL.           (DESY)
HAISSINS 69 ARGONNE CONF. 373  J.HAISSINSKI                         (ORSAY)
JUHALA   69 PR 184  1461       +LEACOCK,RHODE,KOPELMAN,LIBBY,+  (ISU+CCLO)
MALAMUD  69 ARGONNE CONF.P.93  E.MALAMUD, P.SCHLEIN                  (UCLA)
MILLER   69 PR 178 2061        R.MILLER,LICHTMAN,WILLMANN          (PURDUE)
MOTT     69 PR 177 1966        +AMMAR,DAVIS,KROPAC,SLATE,DAGAN+ (NWES+ANL)
REYNOLDS 69 PR 184 1424        +ALBRIGHT,BRADLEY,BRUCKER,HARMS+       (FSU)
ROOS     69 NP B 10 563        M.ROOS,J.PISUT            (CERN+BRATISLAVA)
ROTHWELL 69 PRL 23 1521        +CHASE,EARLES,GETTNER,GLASS,WEINSTEI+(NEAS)
SCHAREN  69 ARGONNE CONF.306   SCHARENGUIVEL                       (PURDUE)
WEHMANN  69 PR 178  2095       +ENGELS,WILSON,+ (HARV+CASE+SLAC+CORN+MCGI)

ALVENSLE 70 PRL 24 786         ALVENSLEBEN,BECKER,BERTRAM,CHEN,COHEN(DESY)
BATON    70 PL 33 B 528        +LAURENS,REIGNIER                   (SACLAY)
BIGGS    70 PRL 24 1197        +BRABEN,CLIFFT,GABATHULER,KITCHING+   (DARE)
BINGHAM  70 PRL 24 955         +FRETTER,MOFFEIT,BALLAM+    (LRL+SLAC+TUFT)
GALLOWAY 70 PR D 1 3077        +MOTT,ALYA,LEE,MARTIN,PRICKETT         (IND)

ABRAMS   71 PR D 4 653         +BARNHAM,BUTLER,COYNE,GOLDHABER,HALL,+(LBL)
BLOODWOR 71 NP B 35 133        BLOODWORTH,JACKSCN,PRENTICE,YOON (TORONTO)
DEERY    71 PR D 3 635         +BISWAS,CASCN,GROVES,JOHNSON,+ (NOTRE DAME)

BAILLON  72 PL 38 B 555        +CARNEGIE,KLUGE,LEITH,LYNCH,RATCLIFF+(SLAC)
BALLAM   72 PR D 5 545         +CHADWICK,BINGHAM,MILBURN,+ (SLAC+LBL+TUFT)
BASDEVAN 72 PL 41 B 178        BASDEVANT,FROGGATT,PETERSEN           (CERN)
BENAKSAS 72 PL 39 B 289        +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE,+(ORSA)
DRIVER   72 NP B 38 1          +HEINLOTH,HOHNE,HOFMANN,RATHJE,+(DESY+HAMB)
EISENBER 72 PR D 5 15          EISENBERG,BALLAM,DAGAN,+   (REHO+SLAC+TELA)
GRAYER   72 PHIL.CCNF.PROC. 5  +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
GRAYER   72 NP B 50 29         +HYAMS,JCNES,WEILHAMMER,BLUM,+  (CERN+MPIM)
JACOBS   72 PR D 6 1291        L.D.JACOBS                          (SACLAY)
RATCLIFF 72 PL 38 B 345        +BULOS,CARNEGIE,KLUGE,LEITH,LYNCH,+  (SLAC)
TAKAHASH 72 PR D 6 1266        TAKAHASHI,BARISH,+      (TOHO+PENN+NDAM+ANL)

BYERLY   73 PR D 7 637         +ANTHONY,COFFIN,MEANLEY,MEYER,RICE,+ (MICH)
CHARLESW 73 NP B 65 253        CHARLESWORTH,EMMS,BELL,+    (RHEL+BIRM+DURH)
GLADDING 73 PR D 8 3721        +RUSSEL,TANNENBAUM,WEISS,THOMSON      (HARV)
HYAMS    73 NP B 64 134        +JONES,WEILHAMMER,BLUM,DIETL,+  (CERN+MPIM)
PROTOPOP 73 PR D 7 1280        PROTOPOPESCU,GARNJOST,GALTIERI,FLATTE+(LBL)

CARROLL  74 PR D 10 1430       +MATTHEWS,WALKER+       (SLAC+DUKE+WISC+TNTO)
ENGLER   74 PR D 10 2070       +KRAEMER,TOAFF,WEISSER,DIAZ+     (CARN+CASE)
ESTABROO 74 NP B 79 301        P.ESTABROOKS,A.D.MARTIN               (DURH)
GOBBI    74 PRL 33 1450        +ROSEN,SCOTT,SHAPIRO+       (NWES+ROCH+CARN)
GRAYER   74 NP B 75 189        G.GRAYER,HYAMS,BLUM,DIETL,+     (CERN+MPIM)
HABER    74 PR D10 1387        +HODOUS,HULSIZER,KISTIAKOWSKY,LEVY+    (MIT)
NORDBERG 74 PL 51 B 106        +ABRAMSON,ANDREWS,HARVEY,+       (CORN+ROCH)
SPITAL   74 PR D 9 126         R.SPITAL,D.R.YENNIE                   (CORN)

ROOS     75 NP B 97 165        M.ROOS                                (HELS)

DEUTSCHM 76 NP B 103 426       +KIRK,+(AACH+BERL+BONN+CERN+CRAC+HEID+WARS)

ANDREWS  77 PRL 38 198         +FUKUSHIMA,HARVEY,LOBKOWICZ,MAY,+     (RCCH)

BALTAY   78 PR D 17 62         +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
BARTALUC 78 NC 44 A 587        BARTALUCCI,BASINI,BERTOLUCCI,    (DESY+FRAS)
QUENZER  78 PL 76 B 512        +RIBES,RUMPF,BERTRAND,BIZOT,CHASE,+  (LALO)
WICKLUND 78 PRD 17 1197        +AYRES,DIEBOLD,GREENE,KRAMER,PAWLICKI (ANL)

BECKER   79 NP B 151  46       +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
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ω(783)

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         1  OMEGA(783,JPG=1--) I=0
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                      1  OMEGA MASS (MEV)

M       64 (779.4)    (1.4)          ARMENTERO 62 HBC     0.0 PBAR P K1K1. 2/74
M      800 (782.0)    (1.0)          ALFF      62 HBC     2.3-2.9 PI+P   . 2/74
M       34 (784.0)    (1.0)          ARMENTERO 63 HBC     0.0 PBAR P     . 2/74
M      220 (781.0)    (2.0)          KRAEMER   64 DBC     1.2 PI+D       . 2/74
M      170 (785.6)    (1.2)          MILLER D  65 HBC    SEEN WITH K+K-  . 2/74
M      666 (786.0)    (1.0)          JAMES     66 HBC     2.1 PI+P       . 2/74
M    R 2198 (783.4)   (0.7)          BALTAY    67 HBC    0.0 PBAR P        2/74
M      155 (779.5)    (1.5)          BARASH    67 HBC     0.0 PBAR P K1K1. 2/74
M          (784.8)    (1.1)          KEY       68 HBC     3 PI-P         . 2/74
M     2400  782.4      0.5           BIZZARRI  69 HBC     0 PBAR P          9/69
M      750  784.1      1.2           ABRAMOVIC 70 HBC     3.9 PI- P         2/74
M   R      (784.0)    (0.7)          ATHERTON  70 HBC    3.6 PBAR P, 7 PI. 2/74
M    F      783.2      1.6           BIGGS     70 CNTR   PHOTOPRODUCTION   2/74
M      260 (781.0)    (2.0)          CASON     70 HBC     8.0 PI-P,4PI   . 2/74
M      250 (784.)     (1.)           DANBURG   70 DBC     1.2 PI+ D      . 2/74
M      500 (786.)     (1.)           DANBURG   70 DBC     1.4 PI+ D      . 2/74
M      600 (784.)     (1.)           DANBURG   70 DBC     1.7 PI+ D      . 2/74
M      500 (786.)     (1.)           DANBURG   70 DBC     1.9 PI+ D      . 2/74
M      400 (785.)     (1.)           DANBURG   70 DBC     2.1 PI+ D      . 2/74
M      200 (785.)     (2.)           DANBURG   70 DBC     2.3 PI+ D      . 2/74
M      248  783.4      1.0           BIZZARRI  71 HBC     0.0 P PBAR K+K- 11/71
M      510  781.0      0.6           BIZZARRI  71 HBC     0.0 P PBAR K1K1 11/71
M   C 4270 (784.1)    (0.3)          COYNE     71 HBC    3.7 PI+ P        11/71
M  D        783.7      1.0           COYNE     71 HBC    3.7 PI+ P        11/71
M      369 (784.0)    (1.4)          MATTHEWS  71 DBC     6.95 PI+ D     . 2/74
M      418  782.5      0.8           AGUILAR   72 HBC    3.9,4.6 K- P     12/72
M  SR 4800 (782.0)    (0.8)          OREN      74 HBC    2.3 PBAR P,5PI   12/75
M  B  7000  782.4      0.5           KEYNE     76 CNTR   PI-P, OMEGA N    12/75
M     2100  783.5      0.8           GESSAROLI 77 HBC    11 PI-P,OMEGA PI 12/77
M      53M  782.7      0.9           APELDOORN 78 HBC    7.2 PB P,PB P OM  4/78*
M     1430  781.8      0.6           COOPER    78 HBC    .7-.8 PB P,5 PI   4/78*
M     3000  782.6      0.8           BENKHEIRI 79 OMEG   9-12 PI+- P      12/79*
M    33260  782.5      0.8           ROOS      79 RVUE   0-3.6 PBAR P     12/79*
M           . . . . . . . . . . .
M   AVG     782.44     0.22    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
M   STUDENT 782.48     0.24    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M  B    OBSERVED BY THRESHOLD-CROSSING TECHNIQUE. MASS RESOL.=4.8 MEV FWHM
M   C   FROM TOTAL SAMPLE OF COYNE 71.  THEY OBSERVE AN IMPORTANT
M   C   CORRELATION BETWEEN SIGMA OF EXP. RESOLUTION AND THE MEAS. MASS.
M  D    FROM BEST-RESOLUTION SAMPLE OF COYNE 71
M   F   FROM OMEGA-RHO INTERFERENCE IN THE PI+PI- MASS SPECTRUM
M   F   ASSUMING OMEGA WIDTH 12.6 MEV.
M   R   INCLUDED IN ROOS 77,79 RVUE
M  S    ERROR INCLUDES 0.5 MEV MASS SCALE ERROR
M

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                      1  OMEGA FULL WIDTH (MEV)

W       34    9.0      3.0           ARMENTERO 63 HBC      0.0 PBAR P
W            13.4      2.0           MILLER D  65 HBC    SEEN WITH K+ K-
W      155   (12.3)   (2.0)          BARASH    67 HBC     SEEN WITH K1 K1 . 6/66
W   C  171   (5.8)    (2.8)          BARASH    67 HBC    0.0 PBAR P,K1 K1 11/71
W      750    8.8      3.0           ABRAMOVIC 70 HBC     3.9 PI- P         6/70
W            11.2      2.7           ATHERTON  70 HBC    3.6 PBAR P, 7 PI   5/70
W      510   10.3      1.4           BIZZARRI  71 HBC     0.0 P PBAR K1K1 11/71
W      248   12.8      3.0           BIZZARRI  71 HBC     0.0 P PBAR K+K- 11/71
W     4270    9.5      1.0           COYNE     71 HBC    3.7 PI+ P        11/71
W      418   13.3      2.            AGUILAR   72 HBC    3.9,4.6 K- P     12/72
W             9.1      0.8           BENAKSAS1 72 OSPK   E+E- COLL.BEAMS   2/73
W            10.5      1.5           BORENSTEI 72 HBC    2.18 K-P          7/77
W  E   940    7.70     1.65          BROWN     72 MMS    2.5 PI- P,N MMS  12/72
W  B 20000   10.22     0.43          KEYNE     76 CNTR   PI-P, OMEGA N    12/75
W     2100    9.4      2.5           GESSAROLI 77 HBC    11 PI-P,OMEGA PI 12/77
W     1430   12.0      2.0           COOPER    78 HBC    .7-.8 PB P,5 PI   4/78*
W          . . . . . . . . . . .
W   AVG      10.11     0.31    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W   STUDENT  10.10     0.35    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W  B    OBSERVED BY THRESHOLD-CROSSING TECHNIQUE. MASS RESOL.=4.8 MEV FWHM
W   C   UNFOLDED BY COYNE 71
W  E    ERROR TAKES ACCOUNT OF SYSTEMATICS ADDED LINEARLY

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Mesons

ω(783)


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                         1  OMEGA PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     OMEGA INTO PI+ PI- PIO                            139+ 139+ 134
P2     OMEGA INTO PI+ PI- (VIOLATES G)                   139+ 139
P3     OMEGA INTO PIO GAMMA                              134+   0
P4     OMEGA INTO PI+ PI- GAMMA                          139+ 139+   0
P5     OMEGA INTO 2PIO GAMMA                             134+ 134+   0
P6     OMEGA INTO ETA GAMMA                              548+   0
P7     OMEGA INTO E+ E-                                   .5+  .5
P8     OMEGA INTO MU+ MU-                                105+ 105
P9     OMEGA INTO ETA PIO (VIOLATES C)                   548+ 134
P10    OMEGA INTO 3 GAMMA                                  0+   0+   0
P11    OMEGA INTO PIO MU+ MU-                            134+ 105+ 105

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

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        P 1          P 2          P 3
 P 1 .8979+-.0050
 P 2   -.3824  .0140+-.0021
 P 3   -.9077     -.0406  .C881+-.0046


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                         1  OMEGA BRANCHING RATIOS

R1     OMEGA INTO NEUTRAL/(PI+ PI- PIO)                 (P3+...)/(P1)
R1              0.17      0.04          ARMENTERO 63 HBC    0.0 PBAR P
R1        20    0.11      0.02          BUSCHBECK 63 HBC    1.5 K-P
R1        35    0.08      0.03          KRAEMER   64 DBC    1.2 PI+D
R1        65    0.10      0.04          ALFF-STEI 66 HBC CORR.BY SCHULTZ(COL)  9/66
R1       850    0.134     0.026         DIGIUGNO  66 CNTR   1.4 PI-P           9/66
R1       348    0.097     0.016         FLATTE    66 HBC    1.8 K-P            9/66
R1              0.06      0.05    0.02  JAMES     66 HBC    2.1 PI+P           6/66
R1        19    0.10      0.03          BARASH    67 HBC    0.0 PBAR P         7/67
R1        46    0.15      0.04          AGUILAR   72 HBC  3.9,4.6 K- P        12/72
R1          . . . . . . . . . .
R1  AVG         0.1065    0.0088  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT     0.106     0.010   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT         0.0982    0.0056 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2     OMEGA INTO (PI+ PI-)/(PI+ PI- PIO). SEE ALSO R15 (P2)/(P1)
R2 R        (0.011)OR MORE  CL=.95   ABRAMOVIC 70 HBC     3.9 PI- P        . 6/70
R2 B         0.014     0.005   0.004 BIGGS     70 CNTR   PHOTOPRODUCTION  12/78*
R2 R        (0.035)OR LESS  CL=.95   BIZZARRI  70 DBC     PBAR N AT REST  11/71
R2          (0.019)OR MORE  CL=.95   CHAPMAN   70 HBC    1.6-2.2 P PBAR    6/70
R2  F        (.002)OR MORE  CL=.90   FLATTE    70 HBC    1.5    K- P       8/69
R2          (0.0026)OR MORE CL=.84   HAGOPIAN  70 HBC    2.3 PI- P         1/71
R2          (0.040)OR LESS  CL=.84   HAGOPIAN  70 HBC    2.3 PI- P         1/71
R2 R         0.022     0.009    0.01 ROOS      70 RVUE                     6/70
R2  A       (0.028)  (0.006)         BEHREND   71 ASPK   PHOTOPRODUCTION .12/78*
R2 S         0.021     0.028   0.009 RATCLIFF  72 ASPK   15.PI- P,N 2PI   12/72
R2          (0.0115)OR MORE          BURNS     73 HBC    .6-1.1 PBAR P    12/75
R2          (0.024)OR MORE  CL=0.95  LYONS     77 HBC    3-4 K-P,LAM OMEG 12/77
R2  A  ASSUMING RHO WIDTH 145 MEV.
R2 B   RE-EVALUATED UNDER R2 BY BEHREND 71 USING MORE ACCURATE OMEGA
R2 B   TO RHO PHOTOPRODUCTION CROSS-SECTION RATIO.
R2  F  FLATTE 70 SEES NO SIGNAL AT 1.7, 2.1, 2.6 GEV/C.
R2 R   ROOS 70 COMBINES ABRAMOVICH 70 AND BIZZARRI 70
R2 S   SIGNIFICANT INTERFERENCE EFFECT OBSERVED.NB OF OMEGA INTO 3PI
R2 S   COMES FROM AN EXTRAPOLATION.
R2          . . . . . . . . . .
R2  AVG         0.0157    0.0040  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  STUDENT     0.0157    0.0044  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2  FIT         0.0155    0.0024 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3     OMEGA INTO (PIO GAMMA) / (PI+ PI- PIO)           (P3)/(P1)
R3          (0.125)  (0.025)OR GRTR. BARMIN    64 PXBC    2.8 PI-P
R3           0.13      0.04          JACQUET   69 HLBC                    10/67
R3           0.081     0.020         BALDIN    71 HLBC   2.9 PI+ P        11/71
R3           0.109     0.025         BENAKSAS2 72 OSPK   E+E- COLL.BEAMS   2/73
R3           0.084     0.013         KEYNE     76 CNTR   PI-P, OMEGA N    12/75
R3          . . . . . . . . . .
R3  AVG         0.0858    0.0097  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  STUDENT     0.090     0.011   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3  FIT         0.0982    0.0056 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4     OMEGA INTO (PI+ PI- GAMMA)/(PI+ PI- PIO)         (P4)/(P1)
R4          (0.05) OR LESS  CL=.90   FLATTE    66 HBC     1.8 K-P          9/66
R4           (.066)OR LESS  CL=.90   KALBFLEI  75 HBC    2.2 K- P,GAMMA + 12/75

R6     OMEGA INTO (MU+ MU-)/(PI+ PI- PIO)(UNITS 10**-3) (P8)/(P1)
R6          (1.2)  OR LESS           GALTIERI  65 HBC     2.7 K-P
R6          (1.7)  OR LESS  CL=.74   FLATTE    66 HBC     1.8 K-P          9/66
R6          (0.2)  OR LESS           WILSON    69 OSPK    12 PI- ON C,FE   9/69

R7     OMEGA INTO (2PIO GAMM)/(PIO GAMMA)               (P5)/(P3)
R7          (0.1)  OR LESS           BARMIN    64 PXBC    1.3-2.8 PI-P
R7          (0.45)   (0.33)          STRUGALSK 69 HLBC    2.34 PI+ N       8/69
R7          (0.14) OR LESS           BALDIN    71 HLBC   2.9 PI+ P        11/71
R7          (0.15) OR LESS  CL=.90   BENAKSAS2 72 OSPK   E+E- COLL. BEAMS  2/73
R7          (0.18) OR LESS  CL=0.95  KEYNE     76 CNTR   PI-P,OMEGA N      7/77

R8     OMEGA INTO (ETA PIO + ETA GAMMA)/(PI+ PI- PIO)   (P9+P6)/(P1)
R8          (0.017)OR LESS  CL=.90   FLATTE    66 HBC     1.8 K-P          9/66
R8          (0.045)OR LESS  CL=.95   JACQUET   69 HLBC                     4/70

R9     OMEGA INTO (NEUTRALS) / (CHARGED)                (P3+...)/(P1+P2...)
R9           0.124     0.021         FELDMAN   67 OSPK    1.2 PI- P        3/67
R9          . . . . . . . . . .
R9  FIT         0.0967    0.0056 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R10    OMEGA INTO (2PIO GAMMA)/(PI+PI-PIO)              (P5)/(P1)
R10         (0.08) OR LESS  CL=.95   JACQUET   69 HLBC                     4/70

R11    OMEGA INTO (ETA GAMMA)/(PIO GAMMA)               (P6)/(P3)
R11         (0.58)   (0.30)          STRUGALSK 69 HLBC    2.34 PI+ N       8/69
R11         (0.40) OR LESS           BALDIN    71 HLBC   2.9 PI+ P        11/71
R11          0.010     0.045         APEL      72 OSPK   4-8 PI- P,N 3GAM  2/73
R11         (0.27) OR LESS  CL=.90   BENAKSAS2 72 OSPK   E+E- COLL. BEAMS  2/73

R12    OMEGA INTO (PIO MU+ MU-) / TOTAL (UNITS 10**-3)  (P11)
R12         (2.)   OR LESS           WEHMANN   68 OSPK   12 PI- FE         6/68

R13    OMEGA INTO (E+ E-)/TOTAL (UNITS 10**-4)          (P7)
R13       3    2.        1.2             BINNIE    65 OSPK    PI-P NEAR THLD.  6/66
R13 H         (1.0)     (1.7)     (0.75) HERTZBACH 67 OSPK ASSUME SU(3)+MIXING 10/66
R13 A    33   (0.65)    (0.13)           ASTVACATU 68 OSPK ASSUME SU(3)+MIXING  6/68
R13            0.40      0.21            BOLLINI1  68 CNTR    1.7PI-P,NOTE Z    9/68
R13 E         (0.76)    (0.14)           AUGUSTI1  69 OSPK    SEE NOTE E        2/72
R13            0.83      0.10            BENAKSAS1 72 OSPK   E+E- COLL.BEAMS    2/73
R13           (0.675)   (0.069)          CORDIER   79 WIRE   E+ E-,3PI         12/79*
R13          . . . . . . . . . .
R13 AVG        0.76      0.17     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
R13 STUDENT    0.77      0.11     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R13 A          NOT RESOLVED  FROM  RHO  DECAY. ERROR STATISTICAL ONLY.
R13 B          MASS RESOLUTION OF BINNIE 65 IS ABOUT 15 MEV.
R13 E          FROM E+ E- COLLIDING BEAMS, ASSUMING OMEGA WIDTH IS
R13 E          (12.2 +/- 1.3) MEV
R13 H          NOT RESOLVED  FROM RHO DECAY.
R13 Z          MASS RESOLUTION OF BOLLINI 1 IS +-10 MEV.HIS ERROR IS +-.15
R13 Z          WITHOUT RHO-OMEGA INTERFERENCE. COMPLETE INTERFERENCE WOULD
R13 Z          CHANGE VALUE BY +-35 PER CENT. THEREFORE WE INCREASED ERROR.

R14    OMEGA INTO NEUTRALS / TOTAL                      (P3+...)
R14            0.084     0.015           BOLLINI   68 CNTR   2.1 PI- P          6/68
R14            0.079     0.019           DEINET    69 OSPK   1.5 PI- P          9/69
R14            0.075     0.025           BIZZARRI  71 HBC     0.0 P PBAR       11/71
R14      42    0.073     0.018           BASILE    72 CNTR   1.67 PI- P         2/73
R14          . . . . . . . . . .
R14 AVG        0.0788    0.0092   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R14 STUDENT    0.0788    0.0098   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R14 FIT        0.0881    0.0046 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R15    OMEGA INTO (PI PI)/(TOTAL). SEE ALSO R2          (P2)
R15            0.032     0.028    0.019 AUGUSTI2  69 OSPK    E+E- COLL.BEAMS   8/69
R15           (0.003)OR MORE  CL=.95    GOLDHABER 69 HBC       3.7-4.0 PI+P   11/69
R15           (0.014)OR MORE  CL=.95    ALLISON   70 HBC     1.3-1.7 PBAR P  . 6/70
R15 B         (0.0080) (0.0028) (0.0022)IGGS      70 CNTR    PHOTOPRODUCTION  12/78*
R15 B    RE-EVALUATED UNDER R2 BY BEHREND 71 USING MORE ACCURATE OMEGA
R15 B    TO RHO PHOTOPRODUCTION CROSS-SECTION RATIO.
R15            0.0122    0.0030         ALVENSLEB 71 CNTR    PHOTOPRODUCTION  11/71
R15            0.013     0.012    0.009 MOFFEIT   71 HBC     2.8,4.7 GAMMA P  11/71
R15            0.036     0.024    0.018 BENAKSAS  72 OSPK     E+E- COLL.BEAMS 12/72
R15 F         (0.035)   (0.018)         BRANDENBU 76 ASPK    13.K-P,PI+PI-    12/79*
R15 F         (0.04)    (0.03)   (0.02) HOLMGREN  77 HBC     4.2 K-P,PI+PI-   12/79*
R15            0.016     0.009    0.007 QUENZER   78 CNTR    E+E- COLL.BEAMS   4/78*
R15 F         (0.010)  (0.001)          WICKLUND  78 ASPK    3,4,6 PI+-PN     12/79*
R15 F    FROM A MODEL DEPENDENT ANALYSIS ASSUMING COMPLETE COHERENCE.
R15          . . . . . . . . . .
R15 AVG        0.0133    0.0027   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R15 STUDENT    0.0133    0.0029   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R15 FIT        0.0140    0.0021 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R16    OMEGA INTO (ETA GAMMA) / (ALL NEUTRALS)          (P6)/(P3+...)
R16           (0.24) OR LESS  CL=.90    DEINET    69 OSPK                      9/69
R16           (0.36) OR LESS  CL=.90    DAKIN     72 OSPK    1.4 PI- P,N MMO  12/72

R17    OMEGA INTO (2 PIO GAMMA) / (ALL NEUTRALS)        (P5)/(P3+...)
R17           (0.19) OR LESS  CL=.90    DEINET    69 OSPK                      9/69
R17 D         (0.22)    (0.07)          DAKIN     72 OSPK    1.4 PI- P,N MMO  12/72
R17 D      SEE R18

R18    OMEGA INTO (PIO GAMMA) / (ALL NEUTRALS)          (P3)/(P3+...)
R18           (0.81) OR MORE  CL=.90    DEINET    69 OSPK                      9/69
R18 D         (0.78)    (0.07)          DAKIN     72 OSPK    1.4 PI- P,N MMO  12/72
R18 D       ERROR STATISTICAL ONLY.AUTHORS OBTAIN GOOD FIT ALSO ASSUMING
R18 D       PIO GAMMA AS THE ONLY NEUTRAL DECAY.

R19    OMEGA INTO (ETA GAMMA)/TOTAL (UNITS 10**-4)      (P6)
R19 A         (3.0)     (2.5)    (1.8)  ANDREWS   77 CNTR  0 6.7-10 GAMMA CU  12/77
R19 B        (29.0)     (7.0)           ANDREWS   77 CNTR  0 6.7-10 GAMMA CU  12/77
R19 A    SOLUTION CORRESPONDING TO CONSTRUCTIVE OMEGA-RHO INTERFERENCE
R19 A    THE QUARK MODEL PREDICTS A RELATIVE DECAY PHASE OF ZERO
R19 B    SOLUTION CORRESPONDING TO DESTRUCTIVE OMEGA-RHO INTERFERENCE

R20    OMEGA INTO (PIO MU+ MU-) / ( MU+ MU-)            (P11)/(P8)          12/78*
R20     30     1.2       0.6            DZHELYADI 79 CNTR  0 25-33 PI- P      12/79*

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REFERENCES FOR OMEGA


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MAGLIC    61 PRL 7 178           B MAGLIC,ALVAREZ,ROSENFELD,STEVENSON  (LRL)
PEVSNER   61 PRL 7 421           PEVSNER,KRAEMER,NUSSBAUM,RICHARD+(JHU+NWES)
XUONG     61 PRL 7 327           NGUYEN HUU XUONG,GERALD R LYNCH       (LRL)

ALFF      62 PRL 9 325           ALFF,BERLEY,COLLEY,GELFAND + (COLU+RUTGERS)
ARMENTER 62 CERN CONF 90         R ARMENTEROS,R BUDDE +     (CERN+CDEF+EPOL)
STEVENSO 62 PR 125 687           STEVENSON,ALVAREZ,MAGLIC,ROSENFELD    (LRL)

ARMENTER 63 SIENA CONF 1 296  ARMENTEROS,EDWARDS,JACOBSEN+      (CERN+CDEF)
BARMIN    63 SIENA CONF 1 207  BARMIN,DOLGOLENKO,KRESTNIKOV+          (ITEP)
BUSCHBEC 63 SIENA CONF 1 166  BUSCHBECK,CZAPP+     (VIENNA+CERN+AMSTERDAM)
GELFAND   63 PRL 11 436        GELFAND,MILLER,NUSSBAUM,RATAU+  (COLU+RUTG)
MURRAY    63 PL 7 358          MURRAY,FERROLUZZI,HUWE,SHAFER,SOLMITZ+(LRL)

BARMIN    64 JETP 18 1289      BARMIN,DOLGOLENKO,KRESTNIKOV +         (ITEP)
KRAEMER   64 PR 136 B 496      KRAEMER,MADANSKY,MEER+        (JHU+NWES+WOOD)

BINNIE    65 PL 18 348         BINNIE,DUANE,JANE,W JONES+        (LOIC+MCHS)
GALTIERI 65 PRL 14 279         A BARBARO GALTIERI,R D TRIPP            (LRL)
MILLER D 65 CU-237(NEVIS 131) DAVID C MILLER  (THESIS)           (COLUMBIA)
    INCLUDES DATA OF GELFAND 63 ABOVE
ALFF-STE 66 PR 145 1072        ALFF-STEINBERGER,BERLEY,BRUGGER+(COLU+RUTG)
ZDANIS    65 PRL 14 721        ZDANIS,MADANSKY,KRAEMER,HERTZBACH+(JHU+BNL)

DIGIUGNO 66 NC 44A 1272        DI GIUGNO,PERUZZI,TROISE+  (NAPL+FRAS+TRST)
FLATTE    66 PR  145  1050     +HUWE,MURRAY,BUTTON-SHAFER,SOLMITZ+    (LRL)
JAMES     66 PR 142 896        F E JAMES,KRAYBILL          (YALE+BROOKHAVEN)

BALTAY    67 PRL  18  93       +FRANZINI,SEVERIENS,YEH,ZANELLO  (COLUMBIA)
BARASH    67 PR  156  1399     BARASH,KIRSCH,MILLER,TAN         (COLUMBIA)
FELDMAN   67 PR 159 1219       +FRATI,GLEESON,HALPERN,NUSSBAUM+     (PENN)
HERTZBAC 67 PR 155, 1461       HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
    ALSO 65 ZDANIS

ASTVACAT 68 PL 27 B  45        ASTVACATUROV,AZIMOV,BALDIN+   (JINR+MOSCOW)
BOLLINI   68 NC 56 A 531       +BUHLER,DALPIAZ,MASSAM+     (CERN+BGNA+STRB)
BOLLINI1 68 NC 57 A 404        +BUHLER,DALPIAZ,MASSAM+     (CERN+BGNA+STRB)
KEY       68 PR 166 1430       +PRENTICE+COOPER+MANNER      (TNTO+ANL+WISC)
PISUT     68 NP B 6 325        J.PISUT,M.ROOS                         (CERN)
WEHMANN   68 PRL 20 748        +ENGELS+ (HARVARD+CASE+SLAC+CORNELL+MCGILL)

AUGUSTI1 69 PL 28 B 513        +BENAKSAS,BUON,GRACCO,HAISSINSKI,+   (ORSAY)
AUGUSTI2 69 LNC 2 214          +LEFRANCOIS,LEHMANN,MARIN,+          (ORSAY)
BIZZARRI 69 NP B 14 169        +FOSTER,GAVILLET,MONTANET,+      (CERN+CDEF)
DANBURG   69 UCRL-19275        JEROME S. DANBURG, THESIS               (LRL)
    ALSO DANBURG 70
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DEINET    69 PL 30 B 426        +MENZIONE,MULLER,BUNIATCV+        (KARL+CERN)
ERWIN     69 NP B 9 364         +WALKER,GOSHAW,WEINBERG      (WISC+PRIN+VAND)
GOLDHABE  69 PRL 23,1351        +BUTLER,COYNE,HALL,MACNAUGHTON,TRILING(LRL)
JACQUET   69 NC 63 A 743        +NGUYEN-KHAC,HAATUFT,HALSTEINSLI(EPOL+BERG)
MILLER    69 PR 178 2061        R.MILLER,LICHTMAN,WILLMANN           (PURDUE)
STRUGALS  69 PL 29 B 532        +CHUVILO,FENYVES,+              (WARS+JINR+BUDA)
WILSON    69 PRIVATE COMM.      RICHARD WILSON (SEE ALSO PR 178 2095)(HARV)

ABRAMOVI  70 NP B 20 209        ABRAMOVICH,BLUMENFELD,BRUYANT,+        (CERN)
BIZZARRI  70 PRL 25 1385        +CIAPETTI,DORE,GASPERO,GUIDONI,+(ROMA+SYRA)
ALLISON   70 PRL 24 618         +COOPER,FIELDS,RHINES                   (ANL)
ATHERTON  70 NP B 18 221        +BLAIR,CELNIKER,DOMINGO,FRENCH+  (CERN+IPN)
BIGGS     70 PRL 24 1201        +CLIFFT,GABATHULER,KITCHING,RAND       (DARE)
CASON     70 PR D 1 851         +ANDREWS,BISWAS,GROVES,HARRINGTON,+  (NDAM)
CHAPMAN   70 NP B 24 445        +DAVIDSON,GREEN,LYS,ROE,VANDER VELDE (MICH)
DANBURG   70 PR D 2 2564        +ABOLINS,DAHL,DAVIES,HOCH,KIRZ,MILLER+(LRL)
FLATTE    70 PR D 1 1           STANLEY M. FLATTE                       (LRL)
GOLDHABE  70 PHILA.CCNF.P.59    GERSON GOLDHABER,REVIEW                 (LRL)
HAGOPIAN  70 PRL 25 1050        S. AND V.HAGOPIAN,BOGART,SELOVE  (FSU+PENN)
ROOS      70 DNPL/R7 P.173      PROC. DARESBURY STUDY WEEKEND NO 1.  (CERN)

ABRAMS    71 PR D 4 653         +BARNHAM,BUTLER,COYNE,GOLDHABER,HALL,+(LBL)
ALVENSLE  71 PRL 27 888         ALVENSLEBEN,BECKER,BUSZA,CHEN,COHEN,+(DESY)
ANGELOW   71 SJNP 12 427        +GRAMENITSKY,KANASIRSKY,KERATSCHEW,+ (JINR)
BALDIN    71 SJNP 13 758        +YERGAKOV,TREBUKHOVSKY,SHISHOV         (ITEP)
BARDADIN  71 PR D4 2711         BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)
BEHREND   71 PRL 27 61          +LEE,NORDBERG,WEHMAN,+        (ROCH+CORN+FNAL)
BIZZARRI  71 NP B 27 140        +MONTANET,NILSSON,D-ANDLAU,+     (CERN+CDEF)
BLOODWOR  71 NP B 35 133        BLOODWORTH,JACKSON,PRENTICE,YOCN  (TORONTO)
CHAPMAN   71 PR D 3 38          +FORTNEY,FOWLER                        (DUKE)
COYNE     71 NP B 32 333        +BUTLER,FANG-LANDAU,MACNAUGHTON         (LRL)
FIELDS    71 PRL 27 1749        +COOPER,RHINES,ALLISON              (ANL+CXF)
MATTHEWS  71 PRL 26 400         +PRENTICE,YOON,CARROLL,WALKER,+ (TNTO+WISC)
MOFFEIT   71 NP B 29 349        +BINGHAM,FRETTER,BALLAM+(LRL+UCB+SLAC+TUFT)

AGUILAR   72 PR D 6 29          AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS    (BNL)
APEL      72 PL 41 B 234        +AUSLANDER,MULLER,BERTOLUCCI,+   (KARL+PISA)
BASILE    72 PHIL.CCNF.PROC153 +BOLLINI,BROGLIN,DALPIAZ,FRABETTI,+   (CERN)
BENAKSAS  72 PL 39 B 289        +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE,+(ORSA)
BENAKSAS172 PL 42 B 507         +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+(ORSAY)
BENAKSAS272 PL 42 B 511         +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+(ORSAY)
BROWN     72 PL 42 B 117        +DOWNING,HOLLOWAY,HULD,BERNSTEIN+(ILL+ILLC)
DAKIN     72 PR D 6 2321        +HAUSER,KREISLER,MISCHKE          (PRINCETON)
EISENBER  72 PR D 5 15          EISENBERG,BALLAM,DAGAN,+    (REHO+SLAC+TELA)
RATCLIFF  72 PL 38 B 345        +BULOS,CARNEGIE,KLUGE,LEITH,LYNCH,+   (SLAC)
BORENSTE  72 PR D 5 1559        BORENSTEIN,DANBURG,KALBFLEISCH,+ (BNL+MICH)

BINNIE    73 PR D 8 2789        +CARR,DEBENHAM,DUANE,GARBUTT,+  (LOIC+SHMP)
BURNS     73 PR D 7 1310        +CONDON,KIM,MANDELKERN,PRICE,SCHULTZ  (UCI)

ESTABROO  74 NP B 81 70         ESTABROOKS,HYAMS,JONES,BLUM,     (CERN+MPIM)
GREGORIO  74 NC 20 A 437        M.A.GREGORIO                  (ICTP-TRIESTE)
KRAMER    74 PRL 33 505         +AYRES,DIEBOLD,GREENE,PAWLICKI+         (ANL)
OREN      74 NP B 71 189        +COOPER,FIELDS,RHINES,ALLISON+     (ANL+OXF)

EMMS      75 NP B98 1           +KINSON,STACEY,BELL,DALE+  (BIRM+DURH+RHEL)
KALBFLEI  75 PR D 11 987        KALBFLEISCH,STRAND,CHAPMAN        (BNL+MICH)
ROOS      75 NP B 97 165        M.ROOS                                 (HELS)

BRANDENB  76 NP B 104 413       BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)
KEYNE     76 PR D 14 28         +BINNIE,CARR,DEBENHAM,GARBUTT,+ (LOIC+SHMP)
     ALSO 73 BINNIE

ANDREWS   77 PRL 38 198         +FUKUSHIMA,HARVEY,LOBKOWICZ,MAY,+     (ROCH)
BARTKE    77 NP B 118 360       + (AACH+BERL+BONN+CERN+CRAC+LOIC+WIEN+WARS)
GESSAROL  77 NP B 126 382       GESSAROLI,+  (BGNA+FIRZ+GENO+MILA+OXF+PAVI)
HOLMGREN  77 PL 66 B 191        +JONGEJANS,ENGELEN,+    (CERN+AMST+NIJM+CXF)
LYONS     77 NP B 125 207       +COOPER,CLARK                           (OXF)
ROOS      77 LNC 19 419         M.ROOS                              (HELSINKI)

APELDOOR  78 NP B 133 245       VAN APELDOORN,GRUNDEMAN,HARTING,+     (ZEEM)
COOPER    78 NP B 146 1         +GURTU,MONTANET,+      (TATA+CERN+CDEF+MADR)
QUENZER   78 PL 76 B 512        +RIBES,RUMPF,BERTRAND,BIZOT,CHASE,+   (LALO)
WICKLUND  78 PRD 17 1197        +AYRES,DIEBOLD,GREENE,KRAMER,PAWLICKI (ANL)

BENKHEIR  79 NP B 150 268       BENKHEIRI,EISENSTEIN,+(EPOL+CERN+CDEF+LALO)
CORDIER   79  LAL-79/1          +DELCOURT,ESCHSTRUTH,FULDA,+          (LALO)
DZHELYAD  79 PL 84 B  143       DZHELYADIN,GOLOVKIN,GRITSUK,+         (SERP)
ROOS      79 LNC                +PELLINEN                              (HELS)
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M(940–953)

66 M(940-953)

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THE CLAIM FOR A NARROW RESONANCE AT 940 MEV BY
CHESHIRE 72 HAS NOT BEEN CONFIRMED BY BINNIE 72,
74, GRAYER 74, BUTTRAM 75. OMITTED FROM TABLE.
THE CLAIM FOR A RESONANCE M(953) IN THE PI+ PI-
GAMMA CHANNEL (AGUILAR 70) HAS NOT BEEN
CONFIRMED. OMITTED FROM TABLE.
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REFERENCES FOR M(940-953)


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AGUILAR   70 PRL 25 1635        AGUILAR-BENITEZ,BASSANO,SAMIOS,BARNES+(BNL)
MAGLICH   71 PRL 27 1479        +OOSTENS,BRODY,CVIJANOVICH (RUTG+PENN+UPNJ)
ROSNER    71 PRL 26 933         J.L.ROSNER,E.W.COLGLAZIER         (MINN+CIT)
AGUILAR   72 PR D 6 29          AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS    (BNL)
CHESHIRE  72 PRL 28 520         +HOFFMAN,GARFINKEL,+         (IOWA+ANL+PURD)
BINNIE    72 PL 39 B 275        +CAMILLERI,DUANE,GARBUTT,BURTON+(LOIC+SHMP)
BINNIE    74 PRL 32 392         +CAMILLERI,CARR,DEBENHAM,+       (LOIC+SHMP)
BUTTRAM   75 PRL 35 970         +CRAWLEY,DUKE,LAMB,LEEPER,PETERSON    (ISU)
GRIGCRIA  75 NP B91 232         GRIGORIAN,LADAGE,MELLEMA,RUDNICK,+   (UCLA)
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η′(958)

2 ETA PRIME(958,JPG=0-+) I=0

Note on the J^P Assignment of η′(958)

From the Dalitz plot analyses of the $\eta' \to \pi\pi\eta$ and $\eta' \to \pi^+\pi^-\gamma$ decays and from the observation of an $\eta' \to \gamma\gamma$ decay mode, all assignments except $J^{PC} = 0^{-+}$ and 2^{-+} are excluded. The Dalitz plot analyses favor spin 0, but cannot rule out spin 2. The indication of anisotropy in the decay of very forward-produced η′ (KALBFLEISCH 73) has not been confirmed by BALTAY 74, thus again favoring spin 0, but still not ruling out spin 2 (LEDNICKY 77).

Two recent analyses, however, seem to have finally established the spin 0 assignment of the η′.

CERRADA 77 perform a partial-wave analysis of the ηππ system produced in the reaction $K^-p \to \eta'\Lambda$, taking into account the η′ and Λ joint decay angular correlations. They conclude that J^P is unambiguously 0^- (see also DELAGUILA 77).

ROUSSARIE 77 analyze a large sample of events from the reaction $\pi^-p \to \eta'n$ at beam momenta just above threshold. They verify that the η′ is produced in a relative S-wave state, and thus the Adair condition is satisfied by their total sample of some 1800 events. The decay angular distribution of the η′ is consistent with isotropy, and thus ROUSSARIE 77 conclude that the spin cannot be 2.

2 ETA PRIME MASS (MEV)

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M   C   CNLY EXPERIMENTS GIVING ERROR LESS THAN 2 MEV KEPT FOR AVERAGING   12/75
M        85 (957.0)                  DAUBER    64 HBC      1.95 K-P
M   K       (958.0)    (1.0)         KALBFLE1  64 HBC      2.7 K-P          6/66
M   K        KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69
M   O       (957.0)    (3.0)         BADIER    65 HBC      3.0 K-P
M   O     8 (960.0)    (2.0)         TRILLING  65 HBC      3.65 PI+ P      12/75
M   O     7 (955.0)   (10.0)         COHN      66 DBC      3.3 PI+D         6/66
M   O       (959.0)    (3.0)         LONDON    66 HBC      2.2 K-P          6/66
M   O       (960.0)    (5.0)         MOTT      69 HBC      4.1-5.5 K- P     7/69
M            957.       1.           RITTENBER 69 HBC      1.7-2.7 K- P     9/69
M   O       (956.0)    (2.0)         AGUILAR   70 HBC     3.9-4.6K-P       12/75
M      3415  956.1      1.1          BASILE1   71 CNTR    1.6 PI- P,N XO   11/71
M       535  957.4      1.4          BASILE1   71 CNTR    1.6 PI- P,N XO   11/71
M      1414  958.2      0.5          DANBURG   73 HBC     2.2 K-P,LAM XO    2/74
M       400  958.       1.           JACOBS    73 HBC     2.9 K-P,LAM XO    1/74
M            957.46     0.33         DUANE     74 MMS     PI- P,N MM        1/74
M            . . . . . . . . .
M   AVG      957.57     0.25    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT  957.57     0.28    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
```

2 ETA PRIME WIDTH (MEV)

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W      85   (4.0)  OR LESS            DAUBER    64 HBC      1.95 K-P
W    3415   (8.)   OR LESS  CL=.90    BASILE1   71 CNTR    1.6 PI- P,N XO   11/71
W     514   (4.7)  OR LESS  CL=.95    DANBURG   73 HBC     2.2 K-P,LAM XO    2/74
W           (0.8)  OR LESS  CL=.95    DUANE     74 MMS     PI- P,N MM        1/74
W    1000    0.28     0.10            BINNIE    79 MMS   0 PI- P,N MM       12/79*
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Mesons

$\eta'(958)$

Data Card Listings

For notation, see key at front of Listings.

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                    2  ETA PRIME PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     ETA PRIME INTO PI+ PI- ETA                       139+ 139+ 548
                      P1(N)  ETAS DECAY INTO ALL NEUTRALS
                      P1(C)  ETAS DECAY CHARGED
P2     ETA PRIME INTO PIO PIO ETA                       134+ 134+ 548
                      P2(N)  ETAS DECAY INTO ALL NEUTRALS
                      P2(C)  ETAS DECAY CHARGED
P3     ETA PRIME INTO PI+ PI- GAMMA                     139+ 139+   0
               (INCLUDING RHO GAMMA)
P4     ETA PRIME INTO GAMMA GAMMA                         0+   0
P5     ETA PRIME INTO OMEGA GAMMA                         C+ 782
P6     ETA PRIME INTO RHOO GAMMA                          0+ 776
P10    ETA PRIME INTO PI+ PI- E+ E-                     139+ 139+  .5+  .5
P11    ETA PRIME INTO 2 PI                              139+ 139
P12    ETA PRIME INTO 3 PI                              139+ 139+ 134
P13    ETA PRIME INTO 4 PI                              139+ 139+ 139+ 139
P14    ETA PRIME INTO 5 PI
P15    ETA PRIME INTO 6 PI
P16    ETA PRIME INTO PIO E+ E- (VIOLATES C IN          134+  .5+  .5
                                    BORN APPROX.)
P17    ETA PRIME INTO ETA E+ E- (VIOLATES C IN          548+  .5+  .5
                                    BORN APPROX.)
P18    ETA PRIME INTO PIO RHO 0 (VIOLATES C)            134+ 776
P19    ETA PRIME INTO PIO CMEGA (VIOLATES C)            134+ 782
P20    ETA PRIME INTO MU+ MU- GAMMA                     105+ 105+   0
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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5
P 1	.4251+-.0174				
P 2	-.6367	.2309+-.0205			
P 3	-.2919	-.5040	.2977+-.0162		
P 4	.0363	-.1140	.0076	.0188+-.0016	
P 5	.0650	-.2002	-.1510	-.0044	.0274+-.0054

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Note on η'(958) Branching Fractions

In our calculation of the branching fractions of the $\eta'(958)$, we use the decay modes $\eta\pi\pi$ (including $\eta\pi^0\pi^0$), $\rho^0\gamma$, $\omega\gamma$, and $\gamma\gamma$. It is assumed that the rate $\eta \to$ neutrals is 71.0%.

In the fit we do not use the constraint

$$R = \frac{\Gamma(\eta' \to \eta\pi^+\pi^-)}{\Gamma(\eta' \to \eta\pi^0\pi^0)} = 2$$

from I-spin conservation. The result of the fit is in agreement with it: $R = 1.8 \pm 0.2$.

```
                    2  ETA PRIME PARTIAL WIDTHS (KEV)

W1     ETA PRIME INTO (GAMMA GAMMA)                     (G1)
W1   C  23   (5.8)    (2.3)        ABRAMS    79 SMAG    E+E-,E+E- RHO GA.12/79*
     C THE SYSTEMATIC ERROR HAS BEEN ADDED LINEARLY.
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                    2  ETA PRIME BRANCHING RATIOS

                    SEE MINI-REVIEW ABOVE.

R1     ETA PRIME INTO (PI+ PI-ETA (NEUTRAL DEC.))/TOTAL (P1N)
R1   K   68   (0.36)   (0.05)      KALBFLE2  64 HBC      2.7 K-P          10/66
R1   K         KALBFLE2 64 SUPERSEDED BY RITTENBERG 69
R1      281    0.314    0.026      RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R1           . . . . . . . . .
R1   FIT       0.302    0.012  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2     ETA PRIME INTO (PI+ PI- NEUTRALS) / TOTAL          (P1N+P2C+P5)
R2       33    0.35     0.06       BADIER    65 HBC      3.0 K-P          10/66
R2       39    0.4      0.1        LONDON    66 HBC      2.2 K-P          10/66
R2           . . . . . . . . .
R2   AVG       0.363    0.051   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2   STUDENT   0.363    0.056   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2   FIT       0.393    0.011  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3     ETA PRIME INTO (PI+ PI- ETA (CHRGD.DECAY))/TOTAL (P1C)
R3   K   44   (0.12)   (0.02)      KALBFLE2  64 HBC      2.7 K-P          10/66
R3   K         KALBFLE2 64 SUPERSEDED BY RITTENBERG 69
R3        7    0.07     0.04       BADIER    65 HBC      3.0 K-P          10/66
R3       10    0.1      0.04       LONDON    66 HBC      2.2 K-P          10/66
R3      107    0.123    0.014      RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R3           . . . . . . . . .
R3   AVG       0.116    0.013   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3   STUDENT   0.116    0.014   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3   FIT       0.1233   0.0C50 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4     ETA PRIME INTO (PI+ PI- NEUTRALS (EXCLUDING       (P2C+P5)
R4         PI+ PI- ETA (NEUTR.DEC.))) / TOTAL
R4   K   10   (0.05)   (0.04)      KALBFLE2  64 HBC      2.7 K-P          10/66
R4   K         KALBFLE2 64 SUPERSEDED BY RITTENBERG 69
R4       42    0.045    0.029      RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R4           . . . . . . . . .
R4   FIT       0.0916   0.0069 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5     ETA PRIME INTO (NEUTRALS) / TOTAL                (P2N+P4)
R5   K   54   (0.25)   (0.05)      KALBFLE2  64 HBC      2.7 K-P          10/66
R5   K         KALBFLE2 64 SUPERSEDED BY RITTENBERG 69
R5       16    0.24     0.17       BADIER    65 HBC      3.0 K-P          10/66
R5       32    0.3      0.1        LONDON    66 HBC      2.2 K-P          10/66
R5      123    0.189    0.026      RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R5      535    0.185    0.022      BASILE1   71 CNTR    1.6 PI- P,N XO    11/71
R5           . . . . . . . . .
R5   AVG       0.190    0.016   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5   STUDENT   0.190    0.018   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R5   FIT       0.185    0.014  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6     ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/TOTAL
R6                                                      (P3)
R6   K   42   (0.22)   (0.04)      KALBFLE2  64 HBC      2.7 K-P          10/66
R6   K         KALBFLE2 64 SUPERSEDED BY RITTENBERG 69
R6       35   (0.34)   (0.09)      BADIER    65 HBC      3.0 K-P         .10/66
R6       20    0.2      0.1        LONDON    66 HBC      2.2 K-P          10/66
R6      298    0.329    0.033      RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R6           . . . . . . . . .
R6   AVG       0.316    0.038   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R6   STUDENT   0.317    0.035   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R6   FIT       0.298    0.016  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R7     ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/(PI PI ETA)
R7                                                      (P3)/(P1+P2)
R7             0.31     0.15       DAVIS     68 HBC      5.5 K- P          9/68
R7           . . . . . . . . .
R7   FIT       0.454    0.036  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R8     ETA PRIME INTO (PIO E+ E-)/TOTAL                 (P16)
R8            (0.013)OR LESS       RITTENBER 65 HBC            2.7 K-P    10/66

R9     ETA PRIME INTO (ETA E+ E-)/TOTAL                 (P17)
R9            (0.011)OR LESS       RITTENBER 65 HBC            2.7 K-P    10/66

R10    ETA PRIME INTO (PIO RHOO)/TOTAL                  (P18)
R10           (0.04) OR LESS       RITTENBER 65 HBC            2.7 K-P    10/66

R11    ETA PRIME INTO(GAMMA OMEGA)/TOTAL                (P5)
R11 R         (0.08) OR LESS       RITTENBER 65 HBC            2.7 K-P    10/66
R11 R    INCLUDES PIO OMEGA
R11           (.05) OR LESS  CL=.90  KALBFLEI 75 HBC     2.2 K- P,GAMMA + 12/75

R12    ETA PRIME INTO (PI+ PI- E+ E-)/TOTAL             (P10)
R12           (0.006)OR LESS       RITTENBER 65 HBC            2.7 K-P    10/66

R13    ETA PRIME INTO (2 PI)/TOTAL                      (P11)
R13           (0.07) OR LESS       LONDON    66 HBC      COMPILATION      10/66

R14    ETA PRIME INTO (3 PI)/TOTAL                      (P12)
R14           (0.07) OR LESS       LONDON    66 HBC      COMPILATION      10/66

R15    ETA PRIME INTO (4 PI)/TOTAL                      (P13)
R15           (0.01) OR LESS       LONDON    66 HBC      COMPILATION      10/66

R16    ETA PRIME INTO (6 PI)/TOTAL                      (P15)
R16           (0.01) OR LESS       LONDCN    66 HBC      COMPILATION      10/66

R17    ETA PRIME INTO (CMEGA GAMMA)/(PI+PI-ETA)         (P5)/(P1)
R17      68    0.068    0.013      ZANFINO   77 ASPK     8.4 PI-P         12/77
R17          . . . . . . . . .
R17 FIT        0.064    0.013  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R18    ETA PRIME INTO (PI+ PI- GAM(INCL.RHO GAM))/(PI PI ETA + CMEGA GAM)
R18                                                     (P3)/(P1+P2+P5)
R18            0.25     0.14       DAUBER    64 HBC      1.95 K-P         10/66
R18          . . . . . . . . .
R18 FIT        0.436    0.034  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R19    ETA PRIME INTO (2 GAMMA)/TOTAL                   (P4)
R19       5    0.055    0.036    0.030 BOLLINI   68 CNTR   1.9 PI- P        12/72
R19       7    0.126    0.075      BENSINGER 70 DBC      2.2 PI+ D        12/72
R19      31    0.020    0.008    0.006 HARVEY    71 OSPK   3.65 PI- P,N XO  11/71
R19      68    0.0171   0.0033     DALPIAZ   72 CNTR     1.6 PI- P,N XO   12/72
R19            0.025    0.007      DUANE     74 MMS      PI-P,N MM        12/75
R19    6000    0.018    0.002      APEL      79 CNTR     15-40 PI- P      12/79*
R19          . . . . . . . . .
R19 AVG        0.0184   0.0016  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R19 STUDENT    0.0184   0.0018  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R19 FIT        0.0188   0.0016 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R20    ETA PRIME INTO (PI+PI-)/TOTAL                    (P11)
R20           (0.02) OR LESS       RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R20           (0.08) OR LESS  CL=.95  DANBURG  73 HBC    2.2 K-P,LAM XO    2/74

R21    ETA PRIME INTO (PI+PI-PIO)/TOTAL                 (P12)
R21           (0.05) OR LESS       RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R21           (0.09) OR LESS  CL=.95  DANBURG  73 HBC    2.2 K-P,LAM XO    2/74

R22    ETA PRIME INTO (PI+PI+PI-PI-)/TOTAL              (P13)
R22           (0.01) OR LESS       RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R22           (0.01) OR LESS  CL=.95  DANBURG  73 HBC    2.2 K-P,LAM XO    2/74

R23    ETA PRIME INTO (PI+PI+PI-PI-PIO)/TOTAL           (P14)
R23           (0.01) OR LESS       RITTENBER 69 HBC      1.7-2.7 K-P

R24    ETA PRIME INTO (PI+PI+PI-PI- NEUTRALS)/TOTAL     (P15+...)
R24           (0.01) OR LESS       RITTENBER 69 HBC      1.7-2.7 K-P       9/69

R25    ETA PRIME INTO (RHOO GAMMA)/(ALL PI+ PI- GAMMA)  (P6)/(P3)
R25            0.94     0.20       AGUILAR   70 HBC      3.9-4.6K-P        1/71
R25  E 473     1.15     0.10       DANBURG   73 HBC      2.2 K-P,LAM XO    2/74
R25  E 473    (0.95) OR MORE  CL=.95  DANBURG  73 HBC    2.2 K-P,LAM XO    2/74
R25  E  EQUIVALENT STATEMENTS
R25     137    1.C1     0.15       JACOBS    73 HBC      2.9 K-P,LAM XO    1/74
R25     615   (1.)                 ROUSSARIE 77 OSPK     1.4 PI-P ETAPR N  1/78
R25          . . . . . . . . .
R25 AVG        1.082    0.077   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R25 STUDENT    1.082    0.086   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R26    ETA PRIME INTO (PIO PIO ETA INTO 3 PIO)/TOTAL    (P2N(3PIO))
R26       4    0.11     0.06       BENSINGER 70 DBC      2.2 PI+ D         1/71
R26          . . . . . . . . .
R26 FIT        0.069    0.006  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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Data Card Listings

For notation, see key at front of Listings.


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R27     ETA PRIME INTO (PI+ PI- GAMMA)/(PI+ PI- ETA(NEUTRAL DEC.))
R27                                                     (P3)/(P1N)
R27 K       (0.54)    (0.10)         AGUILAR   72 HBC     3.9,4.6 K- P       12/72
R27 K   NOT AVERAGED DUE TO COMPLICATION WITH M(953).SEE KALBFLEI 74.
R27    473    0.92      0.14         DANBURG   73 HBC     2.2 K-P,LAM X0      2/74
R27    192    1.11      0.18         JACOBS    73 HBC     2.9 K-P,LAM X0      1/74
R27 P 2603   (1.18)    (0.20)        ROUSSARIE 77 OSPK    1.4 PI-P,ETAPR N 12/77
R27 P   PRELIMINARY RESULT
R27          . . . . . . . . . . .
R27 AVG       0.99      0.11    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R27 STUDENT   0.99      0.12    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R27 FIT       0.986     0.076  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R28     ETA PRIME INTO (2 GAMMA)/(PIO PIO ETA(NEUTRAL DEC.))
R28                                                     (P4)/(P2(N))
R28     16    0.188     0.058        APEL      72 OSPK    3.8 PI- P,N X0      1/73
R28          . . . . . . . . . . .
R28 FIT       0.115     0.015  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R29     ETA PRIME INTO (MU+ MU- GAMMA)/TOTAL(UNITS 10**-5)(P20)              12/78*
R29     25    8.        4.           DZHELYADI 79 CNTR  0 25-33 PI- P        12/79*

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                        2 ETA PRIME C-NONCONSERVING DECAY PARAMETER

          RELATED TEXT SECTICN  VI C

A   DECAY ASYMMETRY PARAMETER FOR PI+ PI- GAMMA
A      152     .07       .08         RITTENBE  65 HBC     2.1-2.7 K-P        12/75
A      103     .00       .10         KALBFLEI  75 HBC     2.2 K-P            12/75
A      295    -.069      .078        GRIGORIA  75 STRC    2.1 PI-P           12/75
A  SP  615   (-.098)    (.053)       ROUSSARIE 77 OSPK    1.4 PI-P ETAPR N    1/78
A  S    SIGN OF ASYMMETRY PARAMETER CHANGED BY US TO CONFORM WITH
A  S    DEFINITION IN TEXT SECTION VI C
A   P   PRELIMINARY RESULT
A            . . . . . . . . . . .
A   AVG      -0.001     0.049   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A   STUDENT  -0.001     0.056   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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REFERENCES FOR ETA PRIME


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DAUBER   64 PRL 13 449         DAUBER,SLATER,SMITH,STORK,TICHO       (UCLA)JP
   ALSO  64 DUBNA CONF 1 418   DAUBER,SLATER,L T SMITH,STORK,TICHO  (UCLA)
GOLDBERG 64 PRL 12 546         +GUNDZIK,LICHTMAN,CONNOLLY,HART,+(SYRA+BNL)
GOLDBERG 64 PRL 13 249         +GUNDZIK,LEITNER,CONNOLLY,HART,+ (SYRA+BNL)
KALBFLE1 64 PRL 12 527         KALBFLEISCH,ALVAREZ,BARBARO-GALTIERI,+(LRL)JP
KALBFLE2 64 PRL 13 349         G.R.KALBFLEISCH,O.DAHL,A.RITTENBERG   (LRL)JP

BADIER   65 PL 17 337          BADIER,DEMOULIN,BARLOUTAUD+(EPOL+SACL+AMST)
KIENZLE  65 PL 19 438          KIENZLE,MAGLIC,LEVRAT,LEFEBVRES +      (CERN)
RITTENBE 65 PRL 15 556         RITTENBERG,KALBFLEISCH              (LRL+BNL)
TRILLING 65 PL 19 427          +BROWN,GOLDHABERS,KADYK,SCANIO          (LRL)

COHN     66 PL 21 347          COHN,MCCULLOCH,BUGG,CONDO  (ORNL+TENN+UCND)
LONDON   66 PR 143 1034        LONDON,RAU,SAMIOS,GOLDBERG + (BNL+SYRACUSE)IJP
MARTIN   66 PL 22,352          MARTIN,CRITTENDEN,SCHROEDER       (INDIANA U)I

BARBARO- 68 PRL 20 349         BARBARO-GALTIERI,MATISON,RITTENBERG+  (LRL)I=0
BARLOUTA 68 PL 26 B  674       BARLOUTAUD+     (SACLAY+AMST+BGNA+REHO+EPOL)I=0
BOLLINI  68 NC 58 A  289       +BUHLER,DALPIAZ,MASSAM+      (CERN+BGNA+STRB)
DAVIS    68 PL 27 B 532        +AMMAR,MOTT,DAGAN,DERRICK,FIELDS (NWES+ANL)

DUFEY    69 PL 29 B 605        +GOBBI,POUCHON,CNOPS,+        (ETH+CERN+SACL)IJP
MOTT     69 PR 177 1966        +AMMAR,DAVIS,KROPAC,SLATE,DAGAN+ (NWES+ANL)
RITTENBE 69  UCRL-18863        ALAN RITTENBERG (THESIS)              (LRL)I=0

AGUILAR  70 PRL 25 1635        AGUILAR-BENITEZ,BASSANO,SAMIOS,BARNES+(BNL)
BENSINGE 70 PL 33 B 505        BENSINGER,ERWIN,THOMPSON,W.D.WALKER   (WISC)

BARDADIN 71 PR D4 2711         BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)
BASILE1  71 NC 3 A 371         +BOLLINI,DALPIAZ,FRABETTI,+(CERN+BGNA+STRB)
BASILE2  71 NP B 33 29         +BOLLINI,DALPIAZ,FRABETTI,+(CERN+BGNA+STRB)
HARVEY   71 PRL 27 885         +MARQUIT,PETERSON,RHOADES,+      (MINN+MICH)
OGIEVETS 71 PL 35 B 69         OGIEVETSKY,TYBOR,ZASLAVSKY            (DUBNA)

AGUILAR  72 PR D 6 29          AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS    (BNL)
APEL     72 PL 40 B 680        +AUSLANDER,MULLER,BERTOLUCCI,+  (KARL+PISA)
BINNIE   72 PL 39 B 275        +CAMILLERI,DUANE,GARBUTT,BURTON+(LOIC+SHMP)
BLOODWOR 72 NP B 39 525        BLOODWORTH,JACKSON,PRENTICE,YOON  (TORONTO)
DALPIAZ  72 PL 42 B 377        +FRABETTI,MASSAM,NAVARRIA,ZICHICHI   (CERN)
RADER    72 PR D 6 3059        +ABOLINS,DAHL,DANBURG,DAVIES,HOCH,+    (LBL)

DANBURG  73 PR D 8 3744        +KALBFLEISCH,BORENSTEIN,CHAPMAN,+(BNL+MICH)  JP
JACOBS   73 PR D 8 18          +CHANG,GAUTHIER,+       (BRAN+UMD+SYRA+TUFT)  JP
KALBFLEI 73 PRL 31 333         KALBFLEISCH,CHAPMAN,+          (BNL+MICH+LBL)  JP

BALTAY   74 PR D9 2999         +COHEN,CSORNA,HABIBI,KALELKAR,+ (COLU+BING)  JP
DUANE    74 PRL 32 425         +BINNIE,CAMILLERI,CARR,DEBENHAM+(LOIC+SHMP)
GAULT    74 NC 24 A 259        +JONES,SCADRON,THEWS         (DURH+LOIC+ARIZ)
KALBFLEI 74 PR D10 916         G.R.KALBFLEISCH                        (BNL)

GRIGORIA 75 NP B91 232         GRIGORIAN,LADAGE,MELLEMA,RUDNICK,+   (UCLA)
KALBFLEI 75 PR D11 987         KALBFLEISCH,STRAND,CHAPMAN        (BNL+MICH)

CERRADA  77 NP B 126 189       +WAGNER,BLOCKZIJL,+    (CERN+AMST+NIJM+OXF)  JP
DELAGUIL 77 PR D16 2833        F.DEL AGUILA AND M.G.DONCEL      (BARCELCNA)  JP
GESSAROL 77 NP B 126 382       GESSAROLI,+  (BGNA+FIRZ+GENO+MILA+OXF+PAVI)
LEDNICKY 77  E2-10521,22,23    R.LEDNICKY                            (JINR)  JP
ROUSSARI 77  PREPRINT          +ERNWEIN,FELTESSE,BORGEAUD,ROUSSARIE+(SACL)  JP
   ALSO  77 BUDAPEST CONF.     HEMINGWAY REVIEW TALK                 (CERN)
ZANFINO  77 PRL 38 930         +BROCKMAN,DANKOWYCH,+ (CARL+MCGI+OHIO+TNTO)

ABRAMS   79  SLAC-PUB 2421     +ALAM,BLOCKER,BOYARSKI,+          (SLAC+LBL)
   ALSO  79 PRL 43 477         ABRAMS,ALAM,BLOCKER,BOYARSKI,+   (SLAC+LBL)
APEL     79 PL 83 B 131        +AUGENSTEIN,BERTOLUCCI(KARL+PISA+SERP+WIEN)
BINNIE   79 PL 83 B 141        +CARR,DEBENHAM,JONES,KARAMI,KEYNE+   (LCIC)
DZHELYAD 79 PL B 88 379        DZHELYADIN,GOLOVKIN,GRITZUK,KACHANOV+(SERP)

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$\delta(980)$

36 DELTA(980,JPG=0+-) I=1

Observations of missing-mass peaks in the 960 MeV mass region are mostly controversial and are therefore not listed here. Under this entry, we list two types of $I=1$ peaks near the $K\bar{K}$ threshold:

1. $\eta\pi$ decays, peaking slightly below the $K\bar{K}$ threshold. This defines $I^G = 1^-$ and $J^P =$ normal.
2. A $K\bar{K}$ threshold enhancement with $I = 1$.

This association is justified by the remark (ASTIER 67) that the $K\bar{K}$ threshold enhancement may be due to a virtual bound state also coupled to the $\eta\pi$ system. In a coupled-channel analysis MORGAN 75 and FLATTE 76 show that the resonance width of the $\delta(980)$ may be much larger than the width observed in the $\eta\pi$ system. Coupled-channel analyses of more recent K^-K^0 and $\eta\pi$ data, however, rule out a large width (IRVING 77, MARTIN 78,79).

The low Q-value of the $K\bar{K}$ threshold enhancement and decay distributions of the $\eta\pi$ system favor $J^P = 0^+$. Additional evidence (LIPKIN 69) comes from the absence of a $\rho\pi$ decay mode (GRASSLER 77).

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                      36  DELTA(980) MASS  (MEV)

M  ETA PI FINAL STATE ONLY.
M      30  980.0     10.0          AMMAR     68 HBC  +-     ,5.5K-,ETA PI  2/73
M      10 (960.)     APPROX.       CHUNG S   68 HBC   -  3.2 PI-P           5/70
M      80 (975.0)                  DEFOIX    68 HBC  +-  1.2 PB P,ETA PI 11/77
M      20  970.0     15.0          BARNES    69 HBC   -  4-5 K-P,PI-ETA     9/69
M          980.      10.           CAMPBELL  69 DBC  +- 2.7 PI+ D           1/73
M      15 (980.0)   (10.0)         MILLER    69 HBC   -  4.5 K-N,ETA PI     7/69
M      21 (948.0)   (7.0)          BARDADIN  71 HBC  +- 8 PI+P,P DO PI     11/77
M     150  972.      10.           DEFOIX    72 HBC  +- 0.7 PBAR P,7 PI     1/73
M  C   70  989.0     10.0          WELLS     75 HBC   - 3.1-6 K-P,ETA PI 11/77
M  CW  20 (988.0)   (9.0)          WELLS     75 HBC  +  3.1-6 K-P,ETA PI 11/77
M      80  981.0      6.0          GAY       76 HBC   - 4.2 K-P,ETA PI     11/77
M   J  80 (974.0)   (9.0)          GAY       76 HBC   - 4.2 K-P,ETA PI     11/77
M          977.0      7.0          GRASSLER  77 HBC   - 16 PI-+P,ETA PI    11/77
M      47  980.      11.           CONFORTO  78 OSPK -  4.5 PI-P,P X-       4/78*
M      50  978.0     16.0          CORDEN    78 OMEG +- 12-15PI-P,ETA PI   4/78*
M   R 145  990.0      7.0          GURTU     79 HBC  +- 4.2 K- P,ETA PI    12/79*
M            . . . . . . . . . . .
M   AVG     981.0     2.8    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT 980.9     3.2    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M  C    SYSTEMATIC ERROR 6 MEV DUE TO ENERGY CALIBRATION ADDED
M   J   USING A TWO CHANNEL RESONANCE PARAMETRIZATION, WITH THE COUPLING
M   J   CONSTANT RATIO (ETA PI)/(K KBAR) FIXED AT SU(3) VALUE OF 2/3.
M    R  FROM D(1285) DECAY
M   W   WEAK EVIDENCE ONLY FOR DELTA+ PRODUCTION

M  K KBAR ONLY, SEE THE TYPED NOTE ABOVE
M     143(1003.3)     7.0+SYSTEMATIC ROSENFELD 65 RVUE +-                 . 8/66
M     100(1016.)     (10.)         ASTIER    67 HBC  +-  0 PBAR P          12/77

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                      36  DELTA(980) WIDTH  (MEV)

W  ETA PI  FINAL STATE ONLY
W      30   80.0     30.0                AMMAR     68 HBC  +-     ,5.5K-,ETA PI  2/73
W      80  (25.0)                        DEFOIX    68 HBC  +-  1.2 PB P,ETA PI 11/77
W      20  (50.0)  OR LESS               BARNES    69 HBC   -  4-5 K-P,PI-ETA  11/77
W           40.      15.                 CAMPBELL  69 DBC  +- 2.7 PI+ D         1/73
W      15   60.0     30.0                MILLER    69 HBC   -  4.5 K-N,ETA PI   2/74
W      21   31.0     28.0                BARDADIN  71 HBC  +- 8 PI+P,P DO PI  . 2/74
W     150  (30.)    (5.)                 DEFOIX    72 HBC  +- 0.7 PBAR P,7 PI . 2/74
W      70  (16.0)   (25.0)    (16.0)     WELLS     75 HBC   - 3.1-6 K-P,ETA PI
W  W   20  (5.0)    (11.0)    (5.0)      WELLS     75 HBC  +  3.1-6 K-P,ETA PI
W  F        80 TO 300                    FLATTE    76 RVUE -  4.2 K-P,ETA PI   11/77
W   N       55.0     15.0                GAY       76 HBC   - 4.2 K-P  ETA PI  11/77
W  J       (72.0)   (51.0)               GAY       76 HBC   - 4.2 K-P  ETA PI  11/77
W           44.0     22.0                GRASSLER  77 HBC   - 16 PI-+P,ETA PI  11/77
W      47   60.      50.       30.       CONFORTO  78 OSPK -  4.5 PI-P,P X-     4/78*
W   D  50   86.0     60.0      50.0      CORDEN    78 OMEG +- 12-15PI-P,ETA PI  4/78*
W   R 145   60.0     20.0                GURTU     79 HBC  +- 4.2 K- P,ETA PI  12/79*
W            . . . . . . . . . . .
W   AVG      51.6     7.5      AVERAGE (ERROR INCLUDES SCALE FACTOR CF 1.0)
W   STUDENT  51.6     8.2      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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Mesons
δ(980), S*(980)

Data Card Listings
For notation, see key at front of Listings.

W F USING A TWO CHANNEL RESONANCE PARAMETRIZATION OF GAY 76 DATA.
W J SEE NOTE J ABOVE .
W N THE ERROR IN THE PAPER IS WRONGLY QUOTED AT ONE POINT
W R FROM D(1285) DECAY
W W WEAK EVIDENCE ONLY FOR DELTA+ PRODUCTION.

W K KEAR ONLY, SEE THE TYPED NOTE ABOVE
W 143 (57.0) 13.0+SYSTEMATIC ROSENFELD 65 RVUE +- 8/66
W 100 (25.) APPROX. ASTIER 67 HBC +- SEE NOTE A ABOVE 9/67
W M (120.) APPROX. MORGAN 75 RVUE 1.2 PBAR P 12/75
W M FROM COUPLED CHANNEL FIT TO DUBOC 72 DATA

36 DELTA(980) PARTIAL DECAY MODES

			DECAY MASSES
P1	DELTA(980)	INTO ETA PI	548+ 134
P2	DELTA(980)	INTO RHO PI	776+ 134
P3	DELTA(980)	INTO K KBAR	497+ 497

36 DELTA(980) BRANCHING RATIOS

R1 DELTA(980) INTO (RHO PI)/(ETA PI) (P2)/(P1)
R1 (0.25) OR LESS CL=.70 AMMAR 70 HBC +- 4.1,5.5K-,ETA PI. 5/70

R2 DELTA(980) INTO (K KBAR)/(ETA PI) (P3)/(P1)
R2 L (0.25) (0.08) DEFOIX 72 HBC +- 0.7 PBAR P 11/77
R2 SEEN GAY 76 HBC - 4.2 K-P ETA PI 11/77
R2 L (0.7) (0.3) CORDEN 78 OMEG 12-15PI-P 4/78*
R2 L FROM THE DECAY OF D(1285).

REFERENCES FOR DELTA(980)

TURKOT 63 SIENNA CONF 1 661 +COLLINS,FUJII,KEMP+ (BNL+PITTSBURGH)

ARMENTER 65 PL 17 344 ARMENTEROS,EDWARDS, JACOBSEN + (CERN+CDEF)
BARASH 65 PR 139 B 1659 +FRANZINI,KIRSCH,MILLER,STEINBERGER+ (CCLU)
KIENZLE 65 PL 19 438 + MAGLIC,LEVRAT,LEFEBVRES + (CERN)
ROSENFEL 65 OXFORD CONF 58 A H ROSENFELD (LRL--RVUE)

ALLEN D 66 PL 22 543 +GP FISHER,G GODDEN,L MARSHALL,SEARS (COLO)G=+
BALTAY 66 PR 142 B 932 +LACH,SANDWEISS,TAFT,YEH,STONEHILL+ (YALE)
FOCACCI 66 PRL 17 890 + KIENZLE,LEVRAT,MAGLIC,MARTIN (CERN)
OOSTENS 66 PL 22 708 +CHAVANON,CROZON,TOCQUEVILLE (SACLAY,CDEF)I=1

ALLISON 67 PL 25B 619 +CRUZ+ (OXF+MPIM+BIRM+RHEL+GLAS+LOIC)
ASTIER 67 PL 25 B 294 +MONTANET,BAUBILLIER,DUBOC+(CDEF+CERN+IRAD)
ASTIER 67 INCLUDES DATA OF BARLOW 67,CONFORTO 67,ARMENTEROS 65.
BAILLON 67 NC 50A 393 +EDWARDS+D-ANDLAU+ASTIER+ (CERN+CDEF+IRAD)
BANNER 1 67 PL 25 B 300 +FAYOUX,HAMEL,ZSEMBERY,CHEZE+ (SACLAY+CAEN)
BANNER 2 67 PL 25 B 569 +CHEZE,HAMEL,MAREL,TEIGER+ (CDEF+SACL)
BARLOW 67 NC 50 A 701 +MONTANET,D-ANDLAU+ (CERN+CDEF+IRAD+LIVP)
CONFORTO 67 NP B3 469 CONFORTO,MARECHAL+ (CERN+CDEF+IPNP+LIVP)

AMMAR 68 PRL 21 1832 +DAVIS,KROPAC,DERRICK,FIELDS,+ (NWES+ANL)
CHUNG S 68 PR 165 1491 +O.DAHL, J. KIRZ, D.H.MILLER (LRL)
DEFOIX 68 PL 28 B 253 +RIVET,SIAUD,CONFORTO+ (CDEF+IPNP+CERN)
GALTIERI 68 PRL 20 349 BARBARO-GALTIERI,MATISON,RITTENBERG+ (LRL)
JUHALA 68 PL 27 B 257 +LEACOCK,RHODE,KOPELMAN,LIBBY+ (IOWA+COLO)
SABRE CO 68 PL 26 B 674 BARLOUTAUD+ (SACL+AMST+BGNA+REHO+EPOL)

BARNES 69 PRL 23 610 +CHUNG,EISNER,BASSANO,GOLDBERG+ (BNL+SYRA)
CAMPBELL 69 PRL 22 1204 J.H.CAMPBELL,LICHTMAN,LOEFFLER,+ (PURDUE)
CRENNELL 69 PRL 22 1398 +KARSHON,KWAN WU LAI,+ (BNL+NYU)
JUHALA 69 PR 184 1461 +LEACOCK,RHODE,KOPELMAN,LIBBY,+ (ISU+COLO)
KRUSE 69 PR 177 1951 KRUSE,LOOS,GOLDWASSER (ILLINOIS)
LIPKIN 69 PRL 22 212 +MESHKOV (REHO+NBS) JP
MILLER 69 PL 29 B 255 D.H.MILLER,S.L.KRAMER,D.D.CARMONY,+(PURDUE)
ALSO 69 PR 188 2011 YEN,AMMANN,CARMONY,ELSNER,+ (PURDUE)
SCHROEDE 69 PR 188 2081 SCHROEDER,KERNAN,FISHER,LIBBY,+ (ISU+CCLO)

ABOLINS 70 PRL 25 469 +GRAVEN,MCCARTHY,G.SMITH,L.SMITH+ (LRL+UCD)
AMMAR 70 PR D 2 430 +KROPAC,DAVIS,DERRICK,+(KANS+NWES+ANL+WISC)
COOPER 70 NP B 23 605 +HANNER,MUSGRAVE,POLLARD,VOYVODIC (ANL)
YIOU 70 THESIS, A 646 TCHIU-PUNG YIOU (ORSAY)

ANDERSON 71 PRL 26 108 +DIXIT,+ (CHIC+ANL+CARL+LASL+CNRC+NAGCYA)
BARDADIN 71 PR 04 2711 BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)

BINNIE 72 PL 39 B 275 +CAMILLERI,DUANE,GARBUTT,BURTON+(LOIC+SHMP)
CHESHIRE 72 PRL 28 520 +HOFFMAN,GARFINKEL,+ (IOWA+ANL+PURD)
DEFOIX 72 NP B 44 125 +NASCIMENTO,BIZZARRI,+ (CDEF+CERN)
DUBOC 72 NP B 46 429 +GOLDBERG,MAKOWSKI,DONALD,+ (LPNP+LIVP)
HOLLOWAY 72 PHIL.CONF.PROC.133+HULD,KOETZ,KRUSE,BERNSTEIN,+ (ILL+ILLC)

ATHERTON 73 PL 43 B 249 +FRANEK,FRENCH,GHIDINI,HILPERT,+ (CERN)

BINNIE 74 PRL 32 392 +CAMILLERI,CARR,DEBENHAM,+ (LOIC+SHMP)
KALBFLEI 74 NP B69 279 KALBFLEISCH,VANDERBURG,+ (BNL+RUTG+IND)
MORGAN 74 PL 51B 71 D.MORGAN (RHEL)

BUTTRAM 75 PRL 35 970 +CRAWLEY,DUKE,LAMB,LEEPER,PETERSON (ISU)
MORGAN 75 ARGONNE CONF. 45 D.MORGAN (RHEL)
WELLS 75 NP B 101 333 +RADOJICIC,ROSCOE,LYONS (OXF)

GAY 76 PL 63 B 220 +CHALOUPKA,BLOKZIJL,HEINEN+(CERN+AMST+NIJM) JP
FLATTE 76 PL 63 B 224 S.M.FLATTE (CERN)

GRASSLER 77 NP B 121 189 + (AACH+BERL+BONN+CERN+CRAC+HEID+WARS)
IRVING 77 PL 70 B 217 A.C.IRVING (LIVERPOOL)
MAY 77 PR D 16 1983 +ABRAMSON,ANDREWS,BUSNELLO,+ (ROCH+CCRN)
MINNAERT 77 PREPRINT MINNAERT (BORDEAUX) J

CONFORTO 78 LNC 23 419 B+G CONFORTO,KEY+(RHEL+TNTO+CHIC+FNAL+WISC)
CORDEN 78 NP B 144 253 +CORBETT,ALEXANDER,+ (BIRM+RHEL+TELA+LOWC)
MARTIN 78 ANP 114 1 A.D.MARTIN,M.R.PENNINGTON (CERN)

ESTABROO 79 PR D 19 2678 P.ESTABROOKS (CARL)
GURTU 79 NP B 151 181 +GAVILLET,BLOKZIJL,+ (CERN+ZEEM+NIJM+OXF)
MARTIN 79 NP B 158 520 +OZMUTLU (DURH)

S*(980)

3 S*(980,JPG=0++) I=0

UNDER THIS ENTRY WE LIST PARAMETERS OF THE POLE IN THE ISOSCALAR S WAVE. FOR A MINI-REVIEW SEE UNDER EPSILON. POSSIBLE EVIDENCE OF D-WAVE PI PI INTERACTIONS IN THIS REGION IS LISTED SEPARATELY UNDER ETA N(1080).

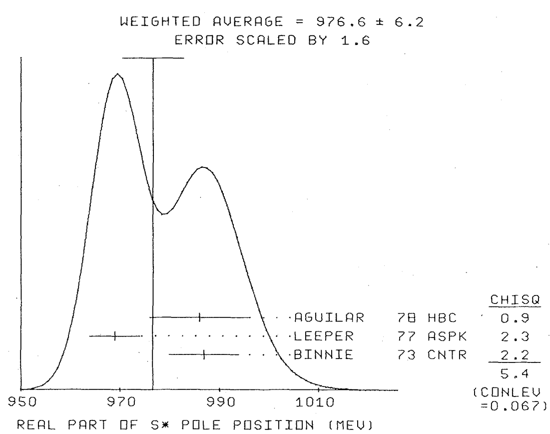
FOR EARLY WORK USING BREIT-WIGNER OR SCATTERING LENGTH PARAMETRIZATION IN FITS TO THE K KBAR MASS SPECTRUM, SEE REFERENCE SECTION AND OUR 1972 EDITION.

3 REAL PART OF THE S* POLE POSITION (MEV)

M	R	(997.)	(6.)	PROTOPOPE	73	HBC	PI+ P	12/77
M		987.	7.	BINNIE	73	CNTR	PI- P,S* N	12/77
M	A	(997.)		ESTABROOK	73	ASPK	17 PI-P,PI+PI-N	12/75
M	R	(1012.)	(6.)	GRAYER	73	ASPK	17 PI-P,PI+PI-N	12/77
M	R	(1007.)	(20.)	HYAMS	73	ASPK	17 PI-P,N PI+PI-	12/77
M	A	(986.)	(5.)	FUJII	75	RVUE	17 PI-P,PI+PI-N	12/75
M		969.0	5.0	LEEPER	77	ASPK	2-2.4 PI-P	12/77
M	C	986.	10.	AGUILAR	78	HBC	.7 PBAR P, KS KS	12/77

M AVG 976.6 6.2 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
M STUDENT 976.9 5.1 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
(SEE IDEOGRAM BELOW)

M A FROM SINGLE CHANNEL FIT TO HYAMS 73 DATA.
M C FROM COUPLED CHANNEL FIT TO HYAMS 73 AND PROTOPOPESCU 73 DATA.
M C WITH A SIMULTANEOUS FIT TO THE PI PI PHASE-SHIFTS,
M C INELASTICITY AND TO THE KS KS INVARIANT MASS.
M R INCLUDED IN AGUILAR 78 FIT



3 NEGATIVE IMAG. PART OF THE S* POLE POSITION (MEV)
CORRESPONDS TO HALF-WIDTH, NOT FULL WIDTH.

W	R	(27.)	(8.)	PROTOPOPE	73	HBC	7. PI+ P	12/77
W		24.	7.	BINNIE	73	CNTR	PI- P,S* N	12/77
W	A	(5.)		ESTABROOK	73	ASPK	17 PI-P,PI+PI-N	12/75
W	R	(16.)	(5.)	GRAYER	73	ASPK	17 PI-P,PI+PI-N	12/77
W	R	(15.)	(5.)	HYAMS	73	ASPK	17 PI-P,N PI+PI-	12/77
W	A	(19.)	(3.)	FUJII	75	RVUE	17 PI-P,PI+PI-N	12/75
W		15.0	4.0	LEEPER	77	ASPK	2-2.4 PI-P	12/77
W	C	50.	40.	AGUILAR	78	HBC	.7 PBAR P, KS KS	12/77

W AVG 17.5 3.9 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
W STUDENT 17.4 3.9 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W ACR SEE NOTES UNDER REAL PART

3 S*(980) PARTIAL DECAY MODES

			DECAY MASSES
P1	S*(980)	INTO K KBAR	497+ 497
P2	S*(980)	INTO PI PI	139+ 139

REFERENCES FOR S*

WANG 61 JETP 13 323 WANG TSU-TSENG,VEKSLER,VRANA,+ (JINR)

BIGI 62 CERN CONF 247 A BIGI,S BRANDT, R CARRARA + (CERN)
BINGHAM 62 CERN CONF 240 H H BINGHAM,M BLOCH + (EPOL+CERN)
ERWIN 62 PRL 9 34 ERWIN,HOYER,MARCH,WALKER,WANGLER (WISC+BNL)

BALTAY 64 DUBNA CONF 1 409 BALTAY,LACH,CRENNELL,OREN,STUMP +(YALE+BNL)
BARMIN 64 DUBNA CONF 1 433 BARMIN,DOLGOLENKO,YEROFEEV,KRESTNI+ (ITEP)

CRENNELL 66 PRL 16 1025 CRENNELL,KALBFLEISCH,LAI,SCARR,SCHU+ (BNL)
HESS 66 PRL 17 1109 +DAHL+HARDY+KIRZ+MILLER (LRL)

BARLOW 67 NC 50A 701 +LILLESTCL+MONTANET+ (CERN+CDEF+IRAD+LIVP)
BEUSCH 67 PL 25 B 357 +FISCHER,GOBBI,ASTBURY+ (ETH+CERN)
DAHL 67 PR 163 1377 +HARDY+HESS+KIRZ+MILLER (LRL)

ALITTI 68 PRL 21 1705 +BARNES,CRENNELL,FLAMINIO,GOLDBERG,+ (BNL)
LAI 68 PHILAD.CONF.P.303 KWAN WU LAI (BNL)
PHELAN 68 THESIS JAMES J. PHELAN (ANL+ST.LOUIS UNIV)
ALSO 68 PRL 21 316 HOANG,EARTLY,PHELAN,ROBERTS+(ANL+CHIC+NDAM)

Data Card Listings

For notation, see key at front of Listings.

Mesons

S*(980), H(990), ϕ(1020)

AGUILAR-	69 PL 29 B 241	M.AGUILAR-BENITEZ,J.BARLOW,+	(CERN+CDEF)
ALSO	67 BARLOW		
ALSO	69 NP B 14 195	M.AGUILAR-BENITEZ,J.BARLOW,+	(CERN+CDEF)
HOANG	69 NC 61 A 325	T.F.HOANG	(ANL)
HOANG	69 PR 184 1363	+EARTLY,PHELAN,ROBERTS,+	(ANL+ILLC)
BADIER	70 NP B 22 512	+BONNET,CREVILLON,BAUBILLIER,+	(EPOL+IPNP)
BATON	70 PL 33 B 528	+LAURENS,REIGNIER	(SACLAY)
BEUSCH	70 PHILA.CONF.P.185	W.BEUSCH	(ETH+CERN)
HYAMS	70 PHILA.CONF.P.41	+KOCH,BEUSCH,+	(CERN+MPIM+ETH+LOIC+HAWA)
ALSO	70 NP B 22 189	HYAMS,KOCH,POTTER,VON LINDERN,+	(CERN+MPIM)
OH	70 PR D 1 2494	+GARFINKEL,MORSE,WALKER,PRENTICE	(WISC+TNTO)
ALSTON-G	71 PL 36 B 152	ALSTON-GARNJOST,BARBARO-GALTIERI,+	(LBL)
BASDEVAN	72 PL 41 B 178	BASDEVANT,FROGGATT,PETERSEN	(CERN)
DAMERI	72 NC 9 A 1	+BORZATTA,GOUSSU,+	(GENO+MILA+SACL)
DUBOC	72 NP B 46 429	+GOLDBERG,MAKOWSKI,DONALD,+	(LPNP+LIVP)
FLATTE	72 PL 38 B 232	+ALSTON-GARNJOST,BARBARO-GALTIERI,+	(LBL)
GRAYER	72 PHIL.CCNF.PROC. 5	+HYAMS,JONES,SCHLEIN,BLUM,DIETL+	(CERN+MPIM)
WILLIAMS	72 PR D 6 3178	P.K.WILLIAMS	(FSU)
BINNIE	73 PRL 31 1534	+CARR,DEBENHAM,DUANE,GARBUTT,+	(LOIC+SHMP)
DIAMOND	73 PR D 7 1977	+BINKLEY,+	(WISC+DUKE+COLO+TNTO+OHIO)
ESTABROO	73 TALLAHASSEE	ESTABROOKS,MARTIN,GRAYER,HYAMS+	(CERN+MPIM)
FUJII	73 NC 13 A 311	Y.FUJII,M.KATO	(TOKYO)
GRAYER	73 TALLAHASSEE	+HYAMS,JONES,BLUM,DIETL,KOCH+	(CERN+MPIM)
HYAMS	73 NP B 64 134	+JONES,WEILHAMMER,BLUM,DIETL,+	(CERN+MPIM)
OCHS	73 THESIS	W.OCHS	(MPIM)
PRCTOPOP	73 PR D 7 1280	PROTOPOPESCU,GARNJOST,GALTIERI,FLATTE+	(LBL)
GRAYER	74 NP B 75 189	+HYAMS,JONES,BLUM,DIETL,KOCH+	(CERN+MFIM)
GRAYER	74 NP B 76 375	+HYAMS,JONES,BLUM,DIETL	(CERN+MPIM)
MORGAN	74 PL 51B 71	D.MORGAN	(RHEL)
FUJII	75 NP B85 179	Y.FUJII,M.FUKUGITA	(TOKY)
MORGAN	75 ARGONNE CONF. 45	D. MORGAN	(RHEL)
PAWLICKI	75 PR D12 631	+AYRES,DIEBOLD,GREENE,KRAMER,WICKLUND	(ANL)
BRANDEB	76 NP B 104 413	+CARNEGIE,CASHMORE,DAVIER,LASINSKI,+	(SLAC)
BUTTRAM	76 PR D 13 1153	+CRAWLEY,DUKE,LAMB,LEEPER,PETERSON	(ISU)
CERRADA	76 PL 62 B 353	+GONZALEZ-ARROYO,RUBIO,YNDURAIN	(CERN+MADR)
FLATTE	76 PL 63 B 228	S.M.FLATTE	(CERN)
WILKINS	76 PR D 13 1831	+ALBRIGHT,S+V HAGOPIAN,LANNUTTI	(FSU)
FROGATT	77 NP B 129 89	+PETERSEN	(GLASGOW+COPENHAGEN)
LEEPER	77 PR D 16 2054	+BUTTRAM,CRAWLEY,DUKE,LAMB,PETERSON	(ISU)
MARTIN	77 NP B 121 514	+OZMUTLU,SQUIRES	(DURHAM)
PAWLICKI	77 PR D 15 3196	+AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND	(ANL)I J
AGUILAR	78 NP B 140 73	+CERRADA,+	(MADRID+BOMBAY+CERN+PARIS)
BALAND	78 NP B 140 220	+GRARD,JOHNSON,+	(MONS+BELG+CERN+LOIC+LALO)
CASON	78 PRL 41 271	+BAUMBAUGH,BISHOP,BISWAS,KENNEY,+	(NDAM+ANL)
COHEN	78 ANL-HEP-PR-78-22	+AYRES,DIEBOLD,KRAMER,PAWLICKI+	(ANL)I,JP
ACHASOV	79 PL B 88 367	+DEVYANIN,SHESTAKOV	(NOVO)
APEL	79 NP B 160 42	+AUSLANDER,MULLER,REHAK+	(KARL+PISA)
BECKER	79 NP B 151 46	+BLANAR,BLUM,CERRADA+	(MPIM+CERN+ZEEM+CRAC)
ESTABROO	79 PR D 19 2678	P.ESTABROOKS	(CARL)
GREENHUT	79 PR D 20 2326	+INTEMANN	(SETO)
LOVERRE	79 CERN/EP 79-162	+ARMENTEROS,DIONISI+	(CERN+CDEF+MADR+STOH)I,JP
MARTIN	79 NP B 158 520	+OZMUTLU	(DURH)I,JP
PCLYCHRO	79 PR D 19 1317	POLYCHRONAKOS,CASON,BISHOP+	(NDAM+ANL)

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H(990)

→ 35 H(990,JPG=A -) I=0

THE EVIDENCE OF BENSON 66 HAS DISAPPEARED AFTER RE-ANALYSIS (CHAUDHARY 70). NO SIGNIFICANT OTHER EVIDENCE HAS BEEN PUBLISHED. OMITTED FROM TABLE.

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REFERENCES FOR H

BARTSCH	64 PL 11 167	AACHEN-ZEUTHEN-BIRM-BONN-HAMB-MUNCHEN COLL	
GOLDHABE	65 CORAL GABLES P.76	G. GOLDHABER	(LRL)
BENSON	66 PRL 17 1234	+MARQUIT,ROE,SINCLAIR,VANDER VELDE	(MICH)IJP
COHN	67 NP B1 57	+MC CULLOCH,BUGG,CONDO	(ORNL+UNIV.TENN)
ROSENFEL	67 RMP 39 1,APPENDIX	ROSENFELD,BARBARO-GALTIERI+	(LRL+CERN+YALE)
ARMENISE	68 PL 26B 336	+GHIDINI,FORINO+	(BARI+BGNA+FIRZ+ORSAY)
BARBARO-	68 PHILAD.CONF.P.137	A.BARBARO-GALTIERI,P.SODING	(LRL)
FUNG	68 PRL 21 47	+JACKSON+PU+BROWN+GIDAL	(U.C.RIVERS+LRL)
GOLDHABE	69 LUND CONF.P.271	G.GOLDHABER QUOTED BY B.MAGLIC	(LRL)
CHAUDHAR	70 PR D 2 2110	B.CHAUDHARY,E.MARQUIT	(MINNESOTA)
GORDON	70 COO 1195 179	THESIS,ILLINOIS	(ILL)
MICHAEL	72 PRL 28 1475	W.MICHAEL,G.GIDAL	(LBL)

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ϕ(1020)

4 PHI(1020,JPG=1--) I=0

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4 PHI MASS (MEV)

M WE ONLY AVERAGE MASS AND WIDTH VALUES WHEN THE

M SYSTEMATIC ERRORS HAVE BEEN EVALUATED.

M	S	18	(1019.0)	(2.0)	SCHLEIN	63	HBC	2.0 K- P	.12/75
M	S	20	(1018.6)	(0.5)	MILLER D	65	HBC	0.0 PBAR P	12/75
M	S	41	(1020.0)	(2.0)	LONDON	66	HBC	2.2 K-P	12/75
M	S	46	(1021.5)	(0.8)	ABRAMS	67	HBC	4.2 K- P	12/75
M	S	15	(1019.)	(3.)	BARLOW	67	HBC	1.2 PBAR P	12/75
M	S	32	(1021.0)	(4.0)	DAHL	67	HBC	1-4 PI- P	12/75
M		165	1022.	1.5	MOSTEK	68	OSPK	1.8 GAMMA + C	6/68
M		136	1018.	0.5	HYAMS	70	OSPK	11. PI- P	12/77
M	AR	107	(1021.0)	(1.5)	ALVENSLE	71	OSPK	GAMMA+C	12/77
M	D	70	1019.9	0.7	DIBIANCA	71	DBC	4.93 K- N	12/75
M		410	(1019.9)	(0.3)	STOTTLEMY	71	HBC	2.9 K-P,Y K KBAR	11/71
M	D	120	1019.6	0.5	AGUILAR	72	HBC	3.9,4.6 K- P	12/75
M	D	100	1019.9	0.5	AGUILAR	72	HBC	3.9,4.6 K- P	12/75
M		87	1020.8	0.8	BALAKIN	72	OSPK	E+ E- COLL.BEAMS	12/72
M		131	1020.4	0.5	COLLEY	72	HBC	10.K+ P,K+ P PHI	12/72
M		100	1020.3	0.4	BALLAM	73	HBC	2.8 - 9.3 G P	1/74
M			1019.4	0.7	BINNIE	73	CNTR	PI-P,PHI N	4/78*
M	AR	500	(1019.5)	(0.6)	AYRES	74	ASPK	3-6PI/K-P,K+K-	12/77
M		984	1019.4	0.8	BESCH	74	CNTR	2 GAMMA P,PK+K-	12/75
M		54	1018.7	0.8	BIZZARRI	74	DBC	0 PBAR N,K+K- PI.	12/75
M		71	1018.6	.7	BIZZARRI	74	DBC	0 PBAR N,KLKS PI	12/75
M	AR	170	(1020.3)	(0.4)	DE GROOT	74	HBC	4.2 K-P,L K+K-	12/77
M			1019.4	0.3	BUKIN	75	ELEC	E+E- COLL.BEAMS	12/77
M		454	1019.7	0.5	KALBFLEIS	76	HBC	2.18 K-P,K KBAR	7/77
M	AR	1300	(1019.7)	(0.2)	AKERLOF	77	SPEC	400 P+A,K+K-	12/77
M	AR	905	(1020.4)	(0.3)	BALDI	77	CNTR	10 K-P,K-PHI P	12/77
M	A	383	(1020.0)	(1.0)	BALDI	77	CNTR	10 PI-P,PI-PHI P	12/77
M	AR	2504	(1020.0)	(0.2)	BALDI	77	CNTR	10 K+P,K+PHI P	12/77
M	AR	721	(1022.0)	(1.0)	BALDI	77	CNTR	10 P P,P PHI P	12/77
M		800	1018.9	0.6	COHEN	77	ASPK	6 PI- PN,K+K-PN	12/77
M			1019.48	0.13	SIDOROV	77	ELEC	E+E- COLL.BEAMS	12/78*
M		256	1019.83	0.19	SIDOROV	77	EMUL	E+ E-,K+ K-	12/78*
M		337	1019.4	0.5	COOPER	78	HBC	.7-.8 PB P,KS KO	4/78*
M		21175	1019.81	0.15	ROOS	79	RVUE		12/79*
M			. . . . .	. . . .					
M	AVG		1019.631	0.094	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)				
M	STUDENT		1019.643	0.091	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
					(SEE IDEOGRAM BELOW)				

M A SYSTEMATIC ERRORS NOT EVALUATED.

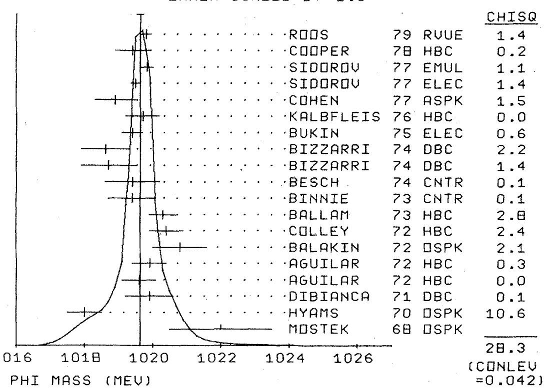
M D MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K* TYPED NOTE

M R INCLUDED IN ROOS 79 RVUE

M S INSIGNIFICANT DATA WITH SMALL STATISTICS NO LONGER AVERAGED

WEIGHTED AVERAGE = 1019.631 ± 0.094

ERROR SCALED BY 1.3



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4 PHI WIDTH (MEV)

W WE ONLY AVERAGE MASS AND WIDTH VALUES WHEN THE

W SYSTEMATIC ERORRS HAVE BEEN EVALUATED.

W	S	20	(3.5)	(1.0)		MILLER D	65	HBC	0.0 PBAR P	.12/75
W	S	41	(6.0)	(4.0)		LONDCN	66	HBC	2.2 K-P	12/75
W	S	46	(1.8)	(3.0)	(1.5)	ABRAMS	67	HBC	4.2 K- P	12/75
W		165	(4.5)	(3.0)	(2.0)	MOSTEK	68	OSPK	1.8 GAMMA + C	6/68
W		150	4.2	0.9		AUGUSTIN	69	OSPK	E+ E- COLL.BEAMS.	12/72
W			4.09	0.29		BIZOT	70	OSPK	E+ E- COLL.BEAMS	12/72
W		136	3.3	1.5		HYAMS	70	OSPK	11. PI- P	6/70
W	D	87	4.67	2.02		BALAKIN	71	OSPK	E+ E- COLL.BEAM	12/75
W	D	70	5.5	2.6		DIBIANCA	71	DBC	4.93 K- N	12/75
W		110	(4.5)	(3.0)	(4.0)	STOTTLEMY	71	HBC	2.9 K-P,Y K KBAR	11/71
W	D	120	4.6	1.7		AGUILAR	72	HBC	3.9,4.6 K- P	12/75
W	D	100	4.7	1.9		AGUILAR	72	HBC	3.9,4.6 K- P	12/75
W	D	131	5.0	1.8		COLLEY	72	HBC	10.K+ P,K+ P PHI	12/75
W	D	454	3.8	0.7		BORENSTEI	72	HBC	2.18 K-P,K KBAR	7/77
W	D	100	3.8	1.5		BALLAM	73	HBC	2.8 - 9.3 G P	12/75
W			4.5	1.1		BINNIE	73	CNTR	PI-P,PHI N	4/78*
W	AD	500	(4.5)	(0.8)		AYRES	74	ASPK	3-6PI/K-P,K+K-	12/75
W	D	984	4.4	0.6		BESCH	74	CNTR	2 GAMMA P,PK+K-	12/75
W	S	54	(6.8)	(3.1)	(2.5)	BIZZARRI	74	DBC	0 PBAR N,K+K- PI	12/75
W	S	71	(4.1)	(3.8)	(3.6)	BIZZARRI	74	DBC	0 PBAR N,KLKS PI	12/75
W			3.81	0.37		COSME 2	74	OSPK	E+E- COLL.BEAMS	2/74
W	AD	170	(4.2)	(1.3)		DE GROOT	74	HBC	4.2 K-P,L K+K-	12/75
W	A	1300	4.5	0.42		AKERLOF	77	SPEC	400 P+A,K+K-	12/77
W		337	3.6	0.7		COOPER	78	HBC	.7-.8 PB P,KS KO	4/78*
W			. . . . .	. . . .						
W	AVG		4.10	0.17	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
W	STUDENT		4.10	0.18	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					

W A SYSTEMATIC ERRORS NOT EVALUATED.

W S INSIGNIFICANT DATA WITH SMALL STATISTICS NO LCNGER AVERAGED

W D WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N), SEE K* TYPED NOTE

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4 PHI PARTIAL DECAY MODES

		DECAY MASSES
P1	PHI INTO K+ K-	493+ 493
P2	PHI INTO KL KS	497+ 497
P3	PHI INTO PI+ PI- PIO (INCLUDING RHO PI)	139+ 139+ 134
P4	PHI INTO ETA GAMMA	548+ 0
P5	PHI INTO E+ E-	.5+ .5
P6	PHI INTO MU+ MU-	105+ 105
P7	PHI INTO PIO GAMMA	134+ 0
P8	PHI INTO PI+ PI- (VIOLATES G)	139+ 139
P9	PHI INTO PI+PI-GAMMA	139+ 139+ 0
P10	PHI INTO OMEGA GAMMA (VIOLATES C)	782+ 0
P11	PHI INTO ETA PIO (VIOLATES C)	548+ 134
P12	PHI INTO RHO GAMMA (VIOLATES C)	776+ 0
P13	PHI INTO ETA NEUTRALS	
P14	PHI INTO 5PI	139+ 139+ 139+ 139+
P15	PHI INTO PI+ PI- PI+ PI- (VIOLATES G)	139+ 139+ 139+ 139

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Mesons
$\phi(1020)$

Data Card Listings
For notation, see key at front of Listings.

FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

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        P 1          P 2          P 3         P 4
P 1  .4861+-.0116
P 2   -.8014   .3517+-.0123
P 3   -.2139     -.3858   .1469+-.0072
P 4   -.1003     -.C848     -.0018  .0153+-.0022
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                    4  PHI BRANCHING RATIOS

R1       PHI INTO (K+ K-)/(K KBAR + PI+ PI- PIO)           (P1)/(P1+P2+P3)
R1  B   27    (0.26)    (0.06)           BADIER    65 HBC                         10/66
R1     252     0.48      0.04            LINDSEY   66 HBC      2.7 K-P            10/66
R1             0.540     0.034           BALAKIN   71 OSPK     E+ E- COLL.BEAM    11/71
R1             0.486     0.044           CHATELUS  71 OSPK    E+ E- COLL.BEAMS    11/71
R1     270     0.49      0.06            DE GROOT  74 HBC     4.2 K-P,L PHI       12/75
R1     321     0.45      0.05            KALBFLEIS 76 HBC     2.18 K-P             7/77
R1          . . . . . . . . . .
R1  AVG        0.497     0.019   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT    0.496     0.022   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT        0.494     0.012  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2       PHI INTO (KL KS)/(K KBAR + PI+ PI- PIO)           (P2)/(P1+P2+P3)
R2  B   25    (0.23)    (0.06)           BADIER    65 HBC                         10/66
R2     167     0.40      0.04            LINDSEY   66 HBC      2.7 K-P            10/66
R2             0.257     0.038           BALAKIN   71 OSPK    E+ E- COLL.BEAMS.   1/73
R2     133     0.27      0.03            KALBFLEIS 76 HBC     2.18 K-P             7/77
R2  A  270    (0.37)    (0.05)           DE GROOT  74 HBC     4.2 K-P,L PHI       12/77
R2  A  SUPERSEDED BY LOSTY 77 UNDER R19.
R2          . . . . . . . . . .
R2  AVG        0.300     0.042   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
R2  STUDENT    0.290     0.026   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2  FIT        0.357     0.012  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R3       PHI INTO (PI+ PI- PIO (INCL.RHO PI))/TOTAL        (P3)
R3 E           0.139     0.007           PARROUR2  76 OSPK     E+E- COLL.BEAMS .  7/77
R3 E     USING TOTAL WIDTH 4.1 MEV. THE 3 PI MODE IS MORE THAN 80 PER CENT
R3 E     RHO PI AT THE 90 PER CENT C.L.
R3          . . . . . . . . . .
R3  FIT        0.1469    0.0072 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R5       PHI INTO (KL KS)/(K KBAR)                         (P2)/(P1+P2)
R5      10     0.40      0.10            SCHLEIN   63 HBC      2.0 K-P            10/66
R5      52     0.48      0.07            BADIER    65 HBC      3.0 K-P            11/67
R5             0.44      0.07            LONDON    66 HBC      2.2 K-P           .10/66
R5          . . . . . . . . . .
R5  AVG        0.448     0.044   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  STUDENT    0.448     0.048   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R5  FIT        0.420     0.014  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R6       PHI INTO (PI+ PI- PIO (INCL.RHO PI))/(K KBAR)     (P3)/(P1+P2)
R6             0.30      0.15            LONDON    66 HBC      2.2 K-P            10/66
R6             0.237     0.039           CERRADA   77 HBC     4.2 K-P,LAM 3PI     12/77
R6          . . . . . . . . . .
R6  AVG        0.241     0.038   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6  STUDENT    0.241     0.041   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R6  FIT        0.175     0.010  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R7       PHI INTO (PI+ PI- PIO (INCL.RHO PI))/(KL KS)      (P3)/(P2)
R7            (0.3)  OR LESS             BERLEY    65 HBC      2.9 PI+P           10/66
R7             0.47      0.06            COSME 1   74 OSPK    E+E- COLL.BEAMS      2/74
R7          . . . . . . . . . .
R7  FIT        0.418     0.030   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R8       PHI INTO (PI+ PI-)/(K KBAR) (SEE ALSO R18)        (P8)/(P1+P2)
R8            (0.2)  OR LESS             LONDON    66 HBC      2.2 K-P            10/66

R9       PHI INTO (E+ E-)/(K+ K-) (UNITS 10**-4)           (P5)/(P1)
R9        (SEE ALSO R16)
R9      40    6.1        1.7             BECKER    68 CNTR         GAMMA C         9/68

R10      PHI INTO (MU+ MU-)/TOTAL (UNITS 10**-4)           (P6)
R10            3.5       3.5       1.8   WEHMANN   68 OSPK    12 K- C              6/68
R10            2.34      1.01            MOY       69 CNTR     PHOTOPROD.         11/70
R10            2.17      0.60            EARLES    70 CNTR     6.0 BREMSSTR.      11/70
R10            2.69      0.46            HAYES     71 CNTR    PHOTOPROD.         .11/71
R10         . . . . . . . . . .
R10 AVG        2.50      0.34    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R10 STUDENT    2.50      0.37    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R11      PHI INTO (ETA GAMMA)/TOTAL                        (P4)
R11      27   (0.073)   (0.019)          BASILE    72 CNTR     1.8 PI- P         .12/78*
R11A     25    0.026     0.007           BENAKSAS  72 OSPK    E+E- COLL.BEAMS .  2/73
R11A     54    0.015     0.004           COSME     76 OSPK    E+E- COLL.BEAMS    12/75
R11B         (0.024)OR LESS  CL=0.95     COSME     76 OSPK    E+E- COLL.BEAMS     7/77
R11            0.0135    0.0029          ANDREWS   77 CNTR    6.7-10 GAMMA CU    12/77
R11A     FROM 2 GAMMA   DECAY MODE OF ETA                                         7/77
R11B     FROM PI+PI-PIO DECAY MODE OF ETA                                         7/77
R11         . . . . . . . . . .
R11 AVG        0.0152    0.0026  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R11 STUDENT    0.0151    0.0025  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R11 FIT        0.0153    0.0022 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R12      PHI INTO (PI+ PI- GAMMA)/TOTAL                    (P9)
R12           (0.04) OR LESS             LINDSEY   65 HBC      2.7 K-P             2/74
R12           (0.007)OR LESS  CL=.90     COSME 1   74 OSPK    E+E- COLL.BEAMS      2/74
R12            (.06) OR LESS  CL=.90     KALBFLEI  75 HBC     2.2 K- P,GAMMA +    12/75

R13      PHI INTO (ETA NEUTRALS)/(K KBAR)                  (P13)/(P1+P2)
R13           (0.15) OR LESS             LINDSEY   66 HBC      2.7 K-P            10/66

R14      PHI INTO (OMEGA GAMMA) / TOTAL                    (P10)
R14           (0.05) OR LESS             LINDSEY   66 HBC      2.7 K-P            10/66

R15      PHI INTO (RHO GAMMA) / TOTAL                      (P12)
R15           (0.02) OR LESS             LINDSEY   66 HBC      2.7 K-P            10/66

R16      PHI INTO (E+ E-)/TOTAL (UNITS 10**-4)             (P5)
R16       (SEE ALSO R9)
R16 A     5    (6.6)     (4.4)     (2.8)   ASTVACATU 68 OSPK    4 PI- P          . 6/68
R16      27    (7.2)     (3.9)             BINNIE    68 OSPK    1.6 PI- P          6/68
R16       9    (6.1)     (2.6)             BOLLINI   68 CNTR    1.9 PI- P          9/68
R16            2.81      0.25              BALAKIN   71 OSPK    E+ E- COLL.BEAMS 11/71
R16            3.50      0.27              CHATELUS  71 OSPK    E+ E- COLL.BEAMS 11/71
R16            3.3       0.3               COSME 1   74 OSPK    E+ E- COLL.BEAMS  2/74
R16  E         3.10      0.14              PARROUR1  76 OSPK    E+ E- COLL.BEAMS  7/77
R16         . . . . . . . . . .
R16 AVG        3.13      0.12     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R16 STUDENT    3.13      0.12     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R16 A     ERROR OF ASTVACATUROV 68 DOES NOT INCLUDE SIGMA(PHI) UNCERTAINTY.
R16  E    USING TOTAL WIDTH 4.2 MEV. THEY DETECT 3 PI MODE AND OBSERVE
R16  E    SIGNIFICANT INTERFERENCE WITH OMEGA TAIL. THIS IS ACCOUNTED FOR
R16  E    IN THE RESULT QUOTED ABOVE

R17      PHI INTO (PIO GAMMA)/(TOTAL)                      (P7)
R17       7    (0.0025) (0.0012)           BENAKSAS  72 OSPK    E+E- COLL. BEAMS  2/73
R17      32     0.0014   0.0005            COSME     76 OSPK    E+ E- COLL.BEAMS 12/77

R18      PHI INTO (PI+ PI-)/(TOTAL) (UNITS 10**-4)         (P8)
R18       (SEE ALSO R8)
R18           (50.)    OR LESS  CL=.95     BIZOT2    70 OSPK    E+ E- COLL.BEAMS 11/71
R18           (80.)    OR LESS  CL=.95     BALAKIN   71 OSPK    E+ E- COLL.BEAMS  1/71
R18            (2.7)   OR LESS  CL=.95     ALVENSLE  72 OSPK    GAMMA+C           1/72

R19      PHI INTO (KL KS)/(K+ K-)                          (P2)/(P1)
R19     144     0.89      0.10             AGUILAR   72 HBC     3.9,4.6 K- P     12/72
R19     125     1.15      0.15             COLLEY    72 HBC     10.K+ P,K+ P PHI 12/72
R19             0.71      0.05             LAVEN     77 HBC     10 K-P,K+K-LAMBD 12/77
R19             0.71      0.08             LYONS     77 HBC     3-4 K-P,LAMB PHI 12/77
R19             0.82      0.08             LOSTY     78 HBC     4.2 K-P,PHI HYP   4/78*
R19         . . . . . . . . . .
R19 AVG         0.774     0.055   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
R19 STUDENT     0.768     0.042   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R19 FIT         0.724     0.041  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)
                          (SEE IDEOGRAM BELOW )
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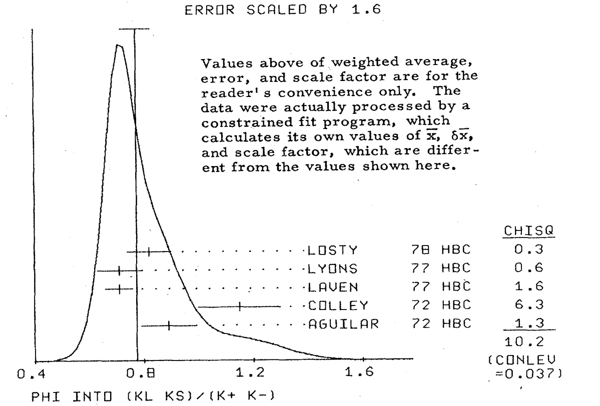
WEIGHTED AVERAGE = 0.774 ± 0.055
ERROR SCALED BY 1.6

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R20      PHI INTO (PI+ PI- PIO(INCL.RHO PI)/(K+ K-)       (P3)/(P1)
R20      34    0.28       0.09           AGUILAR   72 HBC     3.9,4.6 K- P      12/72
R20         . . . . . . . . . .
R20 FIT        0.302      0.018  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R21      PHI INTO (2PI+ 2PI- PIO)/(K+ K-)                  (P14)/(P1)
R21           (0.02) OR LESS  CL=0.95  AGUILAR   72 HBC     3.9,4.6 K- P     .12/72

R22      PHI INTO (PI+ PI- PI+ PI-)/TOTAL (UNITS 10**-4)  (P15)
R22           (8.7)  OR LESS  CL=.90   CORDIER   79 WIRE    E+ E-,4PI           12/79*

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REFERENCES FOR PHI


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BERTANZA 62 PRL 9 180          BERTANZA,BRISSON,CONNOLLY,HART + (BNL+SYRA)
GELFAND  63 PRL 11 438         GELFAND,MILLER,NUSSBAUM,KIRSCH+ (COLU+RUTG)
   GELFAND 63 DATA INCLUDED IN MILLER 65 BELOW
SCHLEIN  63 PRL 10 368         SCHLEIN,SLATER,SMITH,STORK,TICHO       (UCLA)

BADIER   65 PL 17 337          BADIER,DEMOULIN,BARLOUTAUD+      (SACL+AMST)
BERLEY   65 PR 139 B 1097      D BERLEY,N GELFAND             (BNL+COLUMBIA)
GALTIERI 65 PRL 14 279         A BARBARO GALTIERI,R D TRIPP            (LRL)
LINDSEY  65 PRL 15 221         JAMES S LINDSEY,GERALD A SMITH          (LRL)
   LINDSEY 65 DATA INCLUDED IN LINDSEY 66 BELOW
MILLER D 65 CU-237(NEVIS 131) DAVID C MILLER  (THESIS)          (COLUMBIA)

GRAY, L  66 PRL  17  501       +HAGERTY,BIZZARRI,CIAPETTI +    (SYRA+RCMA)JPG
LINDSEY  66 PR  147  913       JAMES S LINDSEY, GERALD A SMITH         (LRL)
LINDSEY1 66 PL 20 93           J.S.LINDSEY, G.A.SMITH                  (LRL)
   LINDSEY 1 66 DATA INCLUDED  IN LINDSEY 66 ABOVE
LONDON   66 PR 143 1034        LONDON,RAU,SAMIOS,GOLDBERG + (BNL+SYRACUSE)

ABRAMS   67 MD TECH REP 720    GERALD ABRAMS , THESIS             (MARYLAND)
BARLOW   67 NC 50A 701         +LILLESTOL+MONTANET+  (CERN+CDEF+IRAD+LIVP)
CHASE    67 PRL 18 710         R.C.CHASE,P.ROTHWELL,R.WEINSTEIN (CEA+NEAS)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER                 (LRL)
HERTZBAC 67 PR 155  1461       HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
KHACHATU 67 PL 248 349         KHACHATURYAN+AZIMOV+BALDIN+BELOUSOV+(DUBNA)

ABRAMS   68 PR 175 1697        +GLASSER,KEHOE,SECHI-ZORN,WOLSKY (MARYLAND)
ASTVACAT 68 PL 27 B  45        ASTVACATUROV,AZIMOV,BALDIN+   (JINR+MOSCOW)
   ALSO  67 PRL 19 869         ASBURY,BECKER,BERTRAM,TING+ (DESY+COLUMBIA)
BECKER   68 PRL 21 1504        +BERTRAM,BINKLEY,JORDAN,KNASEL+  (DESY+MIT)
BINNIE   68 PL 27B 106         +DUANE+FARUQI+HORSEY+             (LOIC+RHEL)
BOLLINI  68 NC 56 A 1171       +BUHLER,DALPIAZ,MASSAM+     (CERN+BGNA+STRB)
MOSTEK   68 PRL 20 1057        +EISENHANDLER,MCCLELLAN,MISTRY+   (CORNELL)
WEHMANN  68 PRL 20 748         +ENGELS+ (HARVARD+CASE+SLAC+CORNELL+MCGILL)
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Data Card Listings

Mesons

For notation, see key at front of Listings. $M(1033-1040)$, $\eta_N(1080)$, $M(1150-1170)$, A_1

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AUGUSTIN 69 PL 28 B 517          +BIZOT,BUON,DELCOURT,HAISSINSKI,+    (ORSAY)
MOY      69  THESIS              KEN MIN MOY        (NORTHEASTERN UNIVERSITY)
SCOTTER  69 NC 62 A 1057         +ERSKINE,PALER,+  (BIRM+GLAS+LOIC+MPIM+OXF)

BIZOT    70 PL 32 416            +BUON,CHATELUS,JEANJEAN,LALANNE,+     (ORSA)
   ALSO  69 PEREZ-Y-JORBA, LIVERPOOL SYMP.69
BIZOT2   70 LNC 4 1273           +DELCOURT,JEANJEAN,LALANNE,+         (ORSAY)
EARLES   70 PRL 25 1312          +FAISSLER,GETTNER,LUTZ,MOY,TANG,+     (NEAS)
HYAMS    70 NP B 22 189          +KOCH,POTTER,V.LINDERN,LORENZ,LUTJENS(CERN)

ALVENSLE 71 PRL 27 441           ALVENSLEBEN,BECKER,BUSZA,CHEN,+  (MIT+DESY)
BALAKIN  71 PL 34 B 328          +BUDKER,PAKHTUSOVA,SIDOROV,SKRINSKY,+(NOVO)
CHATELUS 71  LAL 1247(THESIS) Y.CHATELUS                        (STRASBOURG)
   ALSO  70 BIZOT
DIBIANCA 71 NP B 35 13           +EINSCHLAG,ENDORF,ENGLER,FISK,+       (CORN)
HAYES    71 PR D 4 899           +IMLAY,JOSEPH,KEIZER,STEIN            (CORN)
STOTTLEM 71  ORO 2504 170        A.R.STOTTLEMYER,THESIS            (MARYLAND)

AGUILAR  72 PR D 6 29            AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS   (BNL)
ALVENSLE 72 PRL 28 66            ALVENSLEBEN,BECKER,BIGGS,BINKLEY+(MIT+DESY)
BALAKIN  72 PL 40 B 431          +BOKIN,PAKHTUSOVA,SIDOROV,+   (NOVOSIBIRSK)
BASILE   72 NP B 44 605          +DALPIAZ,FRABETTI,ZICHICHI+(CERN+BGNA+STRB)
BENAKSAS 72 PL 42 B 511          +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+(ORSAY)
BORENSTE 72 PR D 5 1559          BORENSTEIN,DANBURG,KALBFLEISCH,+ (BNL+MICH)
COLLEY   72 NP B 50 1            +JOBES,RIDDIFORD,GRIFFITHS,+    (BIRM+GLAS)

BALLAM   73 PR D 7 3150          +CHADWICK,EISENBERG,BINGHAM,+    (SLAC+LBL)
BINNIE   73 PR D 8 2789          +CARR,DEBENHAM,DUANE,GARBUTT,+  (LOIC+SHMP)

AYRES    74 PRL 32 1463          +DIEBOLD,GREENE,KRAMER,LEVINE,+        (ANL)
BESCH    74 NP B70 257           +HARTMANN,KOSE,KRAUTSCHNEIDER,PAUL,+ (BONN)
BIZZARRI 74 NC 20A 393           +CIAPETTI,DIONISI,DORE,GASPERO+       (RCMA)
COSME 1  74 PL 48 B 155          +JEAN-MARIE,JULLIAN,LAPLANCHE,+      (ORSAY)
COSME 2  74 PL 48 B 159          +JEAN-MARIE,JULLIAN,LAPLANCHE,+      (ORSAY)
DE GROOT 74 NP B74 77            +HOOGLAND,JONGEJANS,METZGER+    (AMST+NIJM)

BUKIN    75  IYAF 75-64          +DERBENEV,KONDRATENKC,KURDADZE,+      (NCVO)
KALBFLEI 75 PR D11 987           KALBFLEISCH,STRAND,CHAPMAN       (BNL+MICH)

COSME    76 PL 63 B 352          +COURAU,DUDELZAK,GRELAUD,JEAN-MARIE+(ORSAY)
KALBFLEI 76 PR D 13 22           KALBFLEISCH,STRAND,CHAPMAN       (BNL+MICH)
PAFROUR1 76 PL 63 B 357          +GRELAUD,COSME,COURAU,DUDELZAK,+     (ORSAY)
PAFROUR2 76 PL 63 B 362          +GRELAUD,COSME,COURAU,DUDELZAK,+     (ORSAY)

AKERLOF  77 PRL 39 861           +ALLEY,BINTINGER,DITZLER,+ (FNAL+MICH+PURD)
ANDREWS  77 PRL 38 198           +FUKUSHIMA,HARVEY,LOBKOWICZ,MAY,+     (ROCH)
BALDI    77 PL 68 B 381          +BOHRINGER,DORSAZ,HUNGERBUHLER,+   (GENEVA)
CERRADA  77 NP B 126 241         +BLOCKZIJL,HEINEN,+     (AMST+CERN+NIJM+OXF)
COHEN    77 PRL 38 269          +AYRES,DIEBOLD,KRAMER,PAWLICKI,WICKLUND(ANL)
COURANT  77 PR D 16 1            +MAKDISI,MARSHAK,PETERSON,RUDDICK,+  (MINN)
EVANGEL  77 NP B 127 384         EVANGELISTA,+    (BARI+BONN+CERN+DARE+GLAS+)
LAVEN    77 NP B 127 43          +OTTER,KLEIN,+    (AACH+BERL+CERN+LOIC+WIEN)
LYONS    77 NP B 125 207         +COOPER,CLARK                          (OXF)
SIDOROV  77 TBILISI VOL.2 B13 V. A. SIDORCV                           (NCVO)

BARTALUC 78 NC 44 A 587          BARTALUCCI,BASINI,BERTOLUCCI+   (DESY+FRAS)
COOPER   78 NP B 146 1           +GURTU,MCNTANET,+      (TATA+CERN+CDEF+MADR)
LOSTY    78 NP B 133 38          +HOLMGREN,BLOKZIJL,+    (CERN+AMST+NIJM+CXF)

CORDIER  79 PL B 81 389          +DELCOURT,ESCHSTRUTH,FULDA,+          (LALO)
ROOS     79 LNC                  +PELLINEN                             (HELS)

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M(1033−1040)

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67  M(1033-1040)

THE CLAIM FOR A NARROW RESONANCE AT 1033 MEV
BY GARFINKEL 72 HAS NOT BEEN CONFIRMED BY
BINNIE 74, GRAYER 74, BUTTRAM 75. OMITTED
FROM TABLE.
THE CLAIM FOR AN OMEGA PI RESONANCE AT 1040
MEV BY DEFOIX 73 HAS NOT BEEN CONFIRMED BY
DIAZ 74. OMITTED FROM TABLE.

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                                 REFERENCES FOR M(1033-1040)

GARFINKE 72 PRL 29 1477          GARFINKEL,HOFFMAN,JACOBEL,+ (PURD+ANL+IOWA)
DEFOIX   73 PL 43 B 141          +DOBRZYNSKI,ESPIGAT,NASCIMENTO,+      (CDEF)
BINNIE   74 PRL 32 392           +CAMILLERI,CARR,DEBENHAM,+       (LOIC+SHMP)
DIAZ     74 PRL 32 260           +DIBIANCA,FICKINGER,ANDERSON,+   (CASE+CARN)
GRAYER   74 NP B 75 189          +HYAMS,JONES,BLUM,DIETL,KOCH+    (CERN+MPIM)
BUTTRAM  75 PRL 35 970           +CRAWLEY,DUKE,LAMB,LEEPER,PETERSON     (ISU)

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$\eta_N(1080)$

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30  ETA N(1080,JPG=N +) I=0 J GREATER THAN 1

SOME EXPERIMENTS SUGGEST J=2. NOT CONFIRMED BY
GRAYER 74, FROGGATT 77. OMITTED FROM TABLE.

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                       30  ETA N MASS (MEV)

M           1060.0     15.0                MILLER    68 HBC     4.0 PI- P        9/68
M        70 1C85.0     10.0                WHITEHEAD 68 ASPK  3.1-3.6 PI-P     10/67
M           1120.0    100.0      40.0      OH        69 HBC     7.PI- P,PI+ D    9/69
M           1112.0     16.0                CLAYTON   70 HBC     2.5 PBAR P,4 PI  1/71
M          (1C80.0)                        DIAZ      70 HBC   0. PBAR P, 4 PI    5/70
M           1070.0     20.0                REYNOLDS  70 HBC    2.26-2.36 PI- P   1/71
M            . . . . . . . . .
M    AVG    1083.3      9.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
M    STUDENT1C83.0      8.3      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                       30  ETA N WIDTH (MEV)

W            (70.0)  OR LESS               MILLER    68 HBC     4.0 PI- P        9/68
W            (25.0)  OR LESS               WHITEHEAD 68 ASPK  3.1-3.6 PI-P     10/67
W            150.0    100.0      40.0      OH        69 HBC     7.PI- P,PI+ D    9/69
W            (80.0)                        CLAYTON   70 HBC     2.5 PBAR P,4 PI  1/71
W            (80.0)                        DIAZ      70 HBC   0. PBAR P, 4 PI    5/70
W             85.0     35.0                REYNOLDS  70 HBC     2.26-2.36 PI- P  1/71
W            . . . . . . . . .
W    AVG      98.0     31.3      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W    STUDENT  S7.7     34.5      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                                 REFERENCES FOR ETA N

MILLER   68 PRL 21 1489          +GUTAY,JOHNSON,KENNEY+    (PURDUE+NDAM+SLAC)
WHITEHEA 68 NC 53 A 817          C.WHITEHEAD +                (AERE+SHMP+LCIC)
OH       69 PRL 23 331           +WALKER,CARROLL,FIREBAUGH,+       (WISC+TNTO)
CLAYTON  70 NP B 22 85           +MASON,MUIRHEAD,RIGOPOULOS,+      (LIVP+ATEN)
DIAZ     70 NP B 16 239          +GAVILLET,LABROSSE,MONTANET,+     (CERN+CDEF)
REYNOLDS 70 NP B 21 77           +ALBRIGHT,BRADLEY,+     (OHIO+FSU+MINN+COLO)
WHITEHEA 72 NP B 48 365          WHITEHEAD,AULD,+        (AERE+RHEL+SHMP+LOUC)
DIAMOND  73 PR D 7 1977          +BINKLEY,+         (WISC+DUKE+COLO+TNTO+OHIO)
GRAYER   74 NP B 75 189          +HYAMS,JONES,BLUM,DIETL,KOCH+     (CERN+MPIM)
FROGATT  77 NP B 129 89          +PETERSEN                 GLASGOW+COPENHAGEN

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M(1150−1170)

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68  M(1150-1170)

THIS ENTRY LISTS REFERENCES TO PEAKS OF LOW
STATISTICAL SIGNIFICANCE IN THE 3 PI SYSTEM
BETWEEN THE A1 AND THE A2, AS WELL AS A CLAIM
FOR A NARROW RESONANCE AT 1150 MEV BY JACOBEL
72, NOT CONFIRMED BY BUTTRAM 75. OMITTED FROM
TABLE.

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                                 REFERENCES FOR M(1150-1170)

BUTTERWO 67 HEIDELB.CCNF.P.28 REVIEW TALK ON MESONS  AT HEIDELBERG CCNF.
CASON    67 PRL 18  880          +LAMSA,BISWAS,DERADO,GROVES,+   (NOTREDAME)
ASCOLI   68 PRL 21 113           +CRAWLEY,KRUSE,MORTARA,SCHAFER,+ (ILLINCIS)
DCNALD   68 PL 26 B  327         +FRODESEN,BETTINI,+  (LIVERPOOL,OSLO,PADUA)
VCN KROG 68 PL 27B 253           +MIYASHITA,KOPELMAN,MARSHALL LIBBY   (CCLO)
JUNKMANN 68 NP B8 471            +COCCONI+           (AACH+BERL+BONN+CERN+WARS)
ARMENISE 69 LNC 2 501            +GHIDINI,FORINO,CARTACCI+  (BARI+BGNA+FIRZ)
GALLOWAY 70 PR D 1 3077          +MOTT,ALYEA,LEE,MARTIN,PRICKETT        (IND)
JACOBEL  72 PRL 29 671           +GARFINKEL,HOFFMAN,+         (IOWA+PURD+ANL)
MORSE    72 NP B 43 77           +OH,WALKER,JOHNSTON,YOON           (WISC+TNTO)
BUTTRAM  75 PRL 35 970           +CRAWLEY,DUKE,LAMB,LEEPER,PETERSON     (ISU)
CORDEN   78 NP B 136 77          +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LCWC)  JP

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$A_1(1100-1300)$

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10  A1(1100-1300,JPG=1+-) I=1
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The peak in the $(3\pi)^{\pm}$ mass distribution near the $\rho\pi$ threshold was discovered by BELLINI 63 in very forward π^- scattering on carbon without nuclear break-up, thus coherent diffractive $\rho\pi$ production.

Until 1977, all the significant observations of a $\rho^0\pi^{\pm}$ peak near 1100 MeV were made in the reaction $\pi^{\pm}N \to (\pi\pi\pi)^{\pm}N$. At small momentum transfer, the diffraction-like mechanism without quantum number exchange in the t channel contributes to this reaction. The dominant effect is a broad $J^P = 1^+$ enhancement in the S-wave $\rho\pi$ system, its width being ~300 MeV (ANTIPOV1 73, OTTER 74, KRUSE 74, TABAK 74, THOMPSON 74, EMMS1 75, BALTAY 77, PERNEGR 78, ROBERTS 78, DAUM 80). The position of the maximum intensity falls in the range 1100 to 1300 MeV and varies with t (DAUM 80).

Most of these experiments have been partial-wave analyzed by the method of ASCOLI 70. Assuming that, for a given momentum transfer t, the 3π vertex is independent of the NN vertex, the 3π vertex is composed, in the spirit of the non-unitary isobar model, of quasi-two-body $\pi\rho$ and $\pi\epsilon$ amplitudes. The waves contributing to the diffractive 3π final state are (at most) the 0^-P, 1^+S, 1^+D, 2^-P, 3^+D, 1^-P, and 2^+D $\rho\pi$ waves and the 0^-S, 1^+P, and 2^-D $\epsilon\pi$ waves. Here ϵ stands for a pole simulating the non-resonant $J^P = 0^+$ $\pi\pi$ interaction in the 700 to 900 MeV region [see the review of

Mesons
A_1(1100–1300)

S-wave ππ interactions under ε(1300)].

The results of these analyses have shown that the phase of the 1^+S wave displays little variation relative to the 0^-S (επ), 1^+P (επ), and 2^-P (ρπ) waves (ANTIPOV1 73, OTTER 74, TABAK 74, THOMPSON 74, BALTAY 77). As the 2^+D wave exhibits a clear Breit-Wigner-like phase change in the A_2 region (ASCOLI 70, ANTIPOV1 73, OTTER 74, TABAK 74, THOMPSON 74, BALTAY 77), the above results have been interpreted to imply that no resonant A_1 is needed. Unitarity corrections to the isobar model did not change this conclusion (ASCOLI 75, AITCHISON 75).

More recent analyses, however, have provided new evidence for an A_1 resonance. BOWLER 75 demonstrated that the small variation in the 1^+S phase could be due to a phase difference between the Deck amplitude and the direct A_1 resonance production amplitude. This small phase variation also could be due to inelasticity, because of the coupling of ρπ to the επ and $K^*\bar{K}$ channels, or to rescattering (BRAYSHAW 76, LONGACRE 76,77). SCHULT 77 reanalyzed the ANTIPOV1 73 data using three-pion-state amplitudes which satisfy both unitarity and analyticity, and found a solution with considerably more phase variation than originally had been observed.

BASDEVANT 77 performed an analysis of the ρπ waves exclusively, ignoring the επ waves as being meaningless in an isobar analysis since the ε could not be considered a bona fide particle. Their full amplitude is properly analytic and unitary, and it includes: the Deck amplitude (resonant as well as background elastic $\rho\pi \to \rho\pi$ scattering), rescattering corrections, inelasticity due to the $K^*\bar{K}$ channel, and direct diffractive A_1 production. They take the 1^+S phase from the difference of the known A_2 phase and the observed $2^+D - 1^+S$ phase difference (ANTIPOV1 73). BASDEVANT 77 show that the ANTIPOV1 73 data are consistent with a resonance at M = 1300 ± 150 MeV, Γ = 400 ± 100 MeV, and that the data are rather inconsistent with the hypothesis of no resonance.

New light has been shed on the existence of the A_1 by the PERNEGR 78 data on coherent π scattering on nuclei. For the first time these data contain information on the $1^+S - 0^-P$ phase difference. Although this phase-shift analysis is ambiguous between two solutions, one solution exhibits a $1^+S - 0^-P$ phase increase of 90° from threshold up to 1400 MeV, together with a peak in the 1^+S intensity around 1100 MeV. The energy dependence of the $1^+S - 0^-P$ phase difference is in fact exactly as predicted by BASDEVANT 77 on the basis of the ANTIPOV1 73 data. Overwhelming confirmation now comes from the very large DAUM 80 experiment on a proton target. They find a unique and stable solution which exhibits not only the $1^+S - 0^-P$ phase increase up to 1400 MeV, but, by comparing with the A_2 phase, they are able to show unambiguously that the 1^+S, 1^+P, and 0^-S phases all increase with mass, the forward motion of the 1^+S phase being ≈80° in the 1100 to 1500 MeV region.

A long-standing problem of the A_1 has been its non-observation in non-diffractive processes (for a review of the situation up to 1976, see HABER 77). Here also the situation is completely changed due to new observations.

GAVILLET 77 have analyzed backwardly produced 3π events in the reaction $K^-p \to \Sigma^-\pi^+\pi^+\pi^-$ in sufficient number to project out the different partial waves. An A_1 peak seen in the total 3π mass distribution can be attributed to the 1^+S partial wave. The Breit-Wigner parameters of the peak are M = 1041 ± 13 MeV, Γ = 230 ± 50 MeV. The SU(3) assignment of an A_1 with these parameters to the $J^{PC} = 1^{++}$ nonet together with the Q's, the D(1285), and the E(1420) is not completely satisfactory and may indicate that the experimental masses are far from the pole positions on the second sheet (MAZZUCATO 79, DIONISI 80). A possible confirmation of backward A_1 production by pions has been obtained by FERRER 78. The observed peak has the resonance parameters M ≅ 1050 MeV, Γ ≅ 200 ± 50 MeV, but nothing is known about the partial-wave composition. The production cross sections at the two different beam momenta of FERRER 78 agree with limits set by earlier, less significant experiments (ANDERSON 69, ABASHIAN 75).

On the other hand, no evidence for the A_1 is found in the charge-exchange reactions $\pi^+n \to \pi^+\pi^-\pi^0p$ (EMMS2 75), $\pi^+p \to \pi^+\pi^-\pi^0\Delta^{++}$ (WAGNER 75, BALTAY 77), $\pi^-p \to \pi^+\pi^-\pi^0n$ (CORDEN 78), or $K^-p \to \pi^+\pi^-\pi^0\Lambda^0$ (CERRADA 77). However, the number of partial waves is greater in charge exchange due to the two possible values of isospin, and thus the analysis is more complicated.

Other non-diffractive channels, such as $\bar{p}p$ annihilation, have not produced consistent results of sufficiently high statistical significance. At best, an A_1^- shoulder has been seen in the $(3\pi)^-$ spectrum from $\bar{p}d \to p\pi^+\pi^-\pi^-\pi^0$. However no A_1^0 is observed. The effect is interpretable as interference between various resonance channels (KASPER 79).

Finally, the semileptonic decay $\tau^\pm \to A_1^\pm\nu$ seems to have been discovered at PLUTO (ALEXANDER 78, WAGNER 79) and confirmed at SLAC-LBL (JAROS 78). The PLUTO $\pi^+\pi^-\pi^\pm$ mass distribution with a $\rho^0\pi^\pm$ selection shows a peak centered at $M \lesssim 1200$ MeV, $\Gamma \sim 400$ to 500 MeV, very unlike phase space. The Dalitz plot distribution is consistent with 1^+S. However, with only 27 events in the plot, it is not possible to rule out all other possible waves.

To summarize, most of the data now seem to require the presence of an A_1 resonance, but the quantitative details are far from being determined exactly. BASDEVANT 78 used the data of ALEXANDER 78 and JAROS 78 to restrict the range of solutions for the A_1 resonance parameters obtained in their analysis of diffractive A_1 production (BASDEVANT 77). The values they obtain, when expressed as second-sheet pole parameters rather than as simple Breit-Wigner parameters are $M \cong 1180 \pm 50$ MeV, $\Gamma = 400 \pm 50$ MeV.

DAUM 80, fitting simultaneously the 1^+S intensity and the phase relative to the 2^+D wave above 1 GeV with model amplitudes similar to the ones used by BOWLER 75 and BASDEVANT 77, find for the A_1 parameters: $M \approx 1280$ MeV, $\Gamma \approx 300$ MeV. This is not in complete agreement with PERNEGR 78, GAVILLET 77, FERRER 78, ALEXANDER 78, and JAROS 78, who find the peak of the 1^+S intensity around 1100 MeV. Thus, if the A_1 can finally be considered as a well established meson, the determination of its parameters is far from settled.

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                  10  A1 MASS (MEV)

M   PRODUCED BY PI +
M        (1C80.0)                          ADERHOLZ  64 HBC      4.0 PI+P
M        (1080.)   APPROX.                 BOESEBECK 68 HBC  +   8 PI+ P           6/68
M        (1040.0)                          ARMENISE  70 HBC    0 9 PI+ N -- A1 P  1/71
M  F     (1128.)     (8.)                  THOMPSO1  74 HBC  +  13 PI+P,P(3PI)+  12/75
M   PRODUCED BY PI -
M        (1060.)                           ASCOLI    68 HBC   -0 5 PI-P          . 6/68
M        (1089.0)   (12.0)                 BALLAM    68 HBC   - 16.0 PI- P          9/68
M        (1090.)   APPROX.                 CHUNG     68 HBC   -  3.2,4.2 PI-P       2/67
M        (1055.0)     (6.0)                JUNKMANN  68 HBC   -  16. PI- P, 5PI     9/69
M   S    (1119.)    (30.)                  KEY       68 HBC   -  3 PI-P             9/68
M   S     SHOULDER ON A2 ONLY
M        (1069.0)     (7.0)                CASO      70 HBC   - 11.2PI-P            5/70
M        (1120.0)                          CRENNELL  70 HBC   -  6. PI- P,F PI      5/70
M  F T   (1150.)                           ANTIPOV1  73 CNTR -  25.,40. PI- P       1/74
M   T  MASS AND WIDTH SEEN TO DEPEND ON T, UNIQUE DET. IMPOSSIBLE                   1/74
M        (1152.0)     (9.0)                BALTAY    77 HBC   0 15 PI- P,P 3PI    12/77
M   P    (1100.0)                          PERNEGR   78 CNTR  - 9+13+15 PI- NUC.   4/78*
M   PD   (1280.0)    (30.0)                DAUM      80 CNTR    63,94 PI- P       12/79*
M   P   PHASE VARIATION OBSERVED BETWEEN (1+S) AND (0-P) WAVES
M    D  FROM A MODEL DEPENDENT FIT.
M
M.  PRODUCED BY PICNS,BACKWARDS SCATT.
M        (1115.0)    (20.0)                ANDERSON  69 MMS   -  16 PI- P,BACKW9   8/69
M   J    (1050.0)    (11.0)                FERRER 2  78 OMEG  - 9+12 PI- P,P 3PI. 4/78*
M   J   NO JP DETERMINATICN ATTEMPTED
M
M   PRODUCED BY PBARS.
M        (1054.)      (7.)                 DANYSZ    67 HBC  +-  3,3.6 PBAR P   . 7/67
M        (1042.)     (21.)                 FRIDMAN   68 HBC  +-  5.7 PBAR P        6/68
M   A    (1076.)      (5.)                 ATHERTON  73 HBC  +- 5.7 PBAR P         1/74
M   A   JP ANALYSIS GIVES SOME EVIDENCE FOR RHO PI D-WAVE
M
M   PRODUCED BY K-.
M        (1111.)     (10.)                 ALLISCN   67 HBC  +   6 K-P,LAM +5 PI  1/68
M        (1117.)     (30.)                 ALLISON   67 HBC  +   6 K-P,LAM +4 PI  1/68
M        (1C60.)     (15.)                 JUHALA    67 HBC    0 4.6-5 K-P,5BODY  1/68
M
M   PRODUCED BY K+.
M   K+   (1060.0)    (20.0)                ALEXANDER 69 HBC  +    9 K+P            9/69
M   K+   (1030.0)    (20.0)                BERLINGHI 69 HBC  + 0 12.7 K+ P         9/69
M   K+  FOR CONTRADICTORY EVIDENCE SEE RABIN 70 .
M
M   PRODUCED BY K-,BACKWARDS SCATTERING
M   F    (1C41.0)    (13.0)                GAVILLET  77 HBC  +  4.2 K- P,S 3PI   12/77
M   F   FRCM A FIT TO JP=1+ RHO PI PARTIAL WAVE
M
M   PRODUCED IN TAU DECAY
M      42(1100.)   APPROX.                 JAROS     78 SMAG +-  E+E-, MU+- 3PI  12/78*
M      27(1200.) OR LESS                   WAGNER    79 PLUT +-  E+E-,E(MU) 3PI  12/79*
M
M   AVERAGING NOT MEANINGFUL

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                  10  A1 WIDTH (MEV)


W   PRODUCED BY PI +
W          (80.0)                          ADERHOLZ  64 HBC      4.0 PI+P
W        (130.)   APPROX.                  BOESEBECK 68 HBC  +   8 PI+ P           6/68
W         (50.0)  OR LESS                  ARMENISE  70 HBC    0 9 PI+ N -- A1 P  1/71
W  F     (300.)   APPROX.                  RINAUDO   71 HBC  +  5. PI+P,P (3PI)+ 11/71
W  F     (367.)     (30.)                  THCMPSO1  74 HBC  +  13 PI+P,P(3PI)+  12/75
W
W   PRODUCED BY PI -
W        (140.0)    (31.0)                 BALLAM    68 HBC   - 16.0 PI- P          9/68
W        (125.)   APPROX.                  CHUNG     68 HBC   -  3.2,4.2 PI-P       2/67
W         (77.0)    (17.0)                 JUNKMANN  68 HBC   -  16. PI- P, 5PI     9/69
W   K     (76.)     (46.)                  KEY       68 HBC   - 3.0 PI- P          11/67
W   K   SHOULDER ON A2 ONLY
W         (99.0)    (15.0)                 CASO      70 HBC   - 11.2PI-P            5/70
W  F T   (300.)                            ANTIPOV1  73 CNTR -  25.,40. PI- P       1/74
W   T  MASS AND WIDTH SEEN TO DEPEND ON T, UNIQUE DET. IMPOSSIBLE                   1/74
W        (264.0)    (11.0)                 BALTAY    77 HBC   0 15 PI+ P,P 3PI    12/77
W   P    (300.0)                           PERNEGR   78 CNTR  - 9+13+15 PI- NUC.   4/78*
W   PD   (300.0)    (30.0)                 DAUM      80 CNTR    63,94 PI- P       12/79*
M   P   PHASE VARIATION OBSERVED BETWEEN (1+S) AND (0-P) WAVES
W    D  FROM A MODEL DEPENDENT FIT.
W
W   PRODUCED BY PICNS,BACKWARDS SCATT.
W         (98.0)    (45.0)    (20.0)       ANDERSON  69 MMS   -  16 PI- P,BACKW9   8/69
W   J    (195.0)    (32.0)                 FERRER 2  78 OMEG  - 9+12 PI- P,P 3PI  4/78*
W   J   NO JP DETERMINATION ATTEMPTED
W
W   PRODUCED BY PBARS.
W         (33.)     (19.)                  DANYSZ    67 HBC  +-  3,3.6 PBAR P      7/67
W        (130.)   APPROX.                  FRIDMAN   68 HBC  +-  5.7 PBAR P        6/68
W   A     (36.)     (20.)     (15.)        ATHERTON  73 HBC  +- 5.7 PBAR P         1/74
W   A   JP ANALYSIS GIVES SOME EVIDENCE FOR RHO PI D-WAVE
W
W   PRODUCED BY K-.
W         (50.)     (50.)                  ALLISCN   67 HBC  +   6 K-P,LAM +4 PI  1/68
W         (50.)     (25.)                  ALLISON   67 HBC  +   6 K-P,LAM +5 PI  1/68
W        (120.)     (15.)                  JUHALA    67 HBC    0 4.6-5 K-P,5BODY  1/68
W
W   PRODUCED BY K+.
W        (160.0)    (20.0)                 ALEXANDER 69 HBC  +    9 K+P            9/69
W   B    (120.0)    (30.0)                 BERLINGHI 69 HBC      12.7 K+ P         8/69
W   K+   FOR CONTRADICTORY EVIDENCE SEE RABIN 70 .
W        (130.0)    (20.0)                 BERLINGHI 69 HBC  + 0 12.7 K+ P         9/69
W
W   PRODUCED BY K-,BACKWARDS SCATTERING.
W   F    (230.0)    (50.0)                 GAVILLET  77 HBC  +  4.2 K- P,S 3PI   12/77
W   F   FROM A FIT TO JP=1+ RHO PI PARTIAL WAVE
W
W   PRODUCED IN TAU DECAY
W      42 (200.)   APPROX.                 JAROS     78 SMAG +-  E+E-, MU+- 3PI  12/78*
W      27  400. TO 500.                    WAGNER    79 PLUT +-  E+E-,E(MU) 3PI  12/79*
W
W   AVERAGING NOT MEANINGFUL

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                  10  A1 PARTIAL DECAY MCDES

                                                            DECAY MASSES
P1      A1 INTO RHO PI                                    776+ 139
P2      A1 INTO KBAR K                                    493+ 497
P3      PI (PI PI) S WAVE                                 139+ 139+ 139

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                  10  A1 BRANCHING RATIOS

R1      A1 INTO (KBAR K)/(RHO PI)                      (P2)/(P1)
R1            (0.0025)OR LESS          DAHL      67 HBC  -  4.0 PI- P        .10/66

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Mesons

A_1(1100–1300), B(1235)

Data Card Listings

For notation, see key at front of Listings.

REFERENCES FOR A1


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BELLINI   63 NC 29 896            BELLINI,FIORINI,HERZ,NEGRI,RATTI      (MILAN)

ADERHOLZ  64 PL 10 226            AACH+BERL+BIRM+BONN+DESY+HAMBURG+LOIC+MPIM
GOLDHABE  64 PRL 12 336           GOLDHABER,BROWN,KADYK,SHEN+          (LRL+UCB)
LANDER    64 PRL 13 346 A         LANDER,ABOLINS,CARMONY,HENDRICKS +    (UCSD)  JP

ABOLINS   65 ATHENS(OHIO)CONF.    +CARMONY,LANDER,XUONG,YAGER        (LA JOLLA)I=1
ALITTI    65 PL 15 69             ALITTI,BATON,DELER,CRUSSARD+      (SACL+BGNA)

ALLARD    66 NC 46A 737           +DRIJARD+HENNESSY+     (ORSAY+MILAN+SACL+UCB)
DEUTSCHM  66 PL 20 82             DEUTSCHMANN,STEINBERG +  (AACH+BERLIN+CERN)
HESS      66 UCRL-16832           R I HESS (THESIS, BERKELEY)              (LRL)

ALLISON   67 PL 25B 619           +CRUZ+           (OXF+MPIM+BIRM+RHEL+GLAS+LOIC)
DAHL      67 PR 163 1377          +HARDY+HESS+KIRZ+MILLER                  (LRL)
DANYSZ    67 NC 51 A 801          DANYSZ+FRENCH+SIMAK                     (CERN)
JUHALA    67 PRL 19 1355          +LEACOCK+RHODE+KOPELMAN+           (IOWA+COLO)
SLATTERY  67 NC 50A 377           +KRAYBILL+FORMAN+FERBEL            (YALE+ROCH)  JP

ARMENISE  68 PL 26 B  336         +FORINO+CARTACCI+       (BARI+BGNA+FIRZ+ORSAY)
ASCOLI    68 PRL 21 113           +CRAWLEY,KRUSE,MORTARA,SCHAFER,+ (ILLINOIS)
BALLAM    68 PRL 21 934           +BRODY,CHADWICK,FRIES,GUIRAGOSSIAN+  (SLAC)JP
BOESEBEC  68 NP B 4 501           BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO      68 NC 54 A 983          +CONTE+CORDS+DIAZ+  (GENOVA+HAMB+MILA+SACL)
CHUNG     68 PR 165 1491          S.U.CHUNG,C.DAHL,J.KIRZ,D.H.MILLER      (LRL)
CNOPS     68 PRL 21 1609          +HOUGH,COHN,BUGG+ (BNL+CRNL+UCND+TENN+PENN)
FRIDMAN   68 PR 167 1268          +MAURER,MICHALON,OUDET+    (HEID+STRASBOURG)
JUNKMANN  68 NP B8 471            +COCCONI+            (AACH+BERL+BONN+CERN+WARS)
KEY       68 PR 166 1430          +PRENTICE+COOPER+MANNER+     (TNTO+ANL+WISC)

ALEXANDE  69 PR 183 1168          G.ALEXANDER,A.FIRESTONE,G.GOLDHABER    (LRL)
ALLABY    69 PL 29B 198           +BINON+DIDDENS+DUTEIL+KLOVNING+...    (CERN)
ANDERSON  69 PRL 22 1390          +COLLINS,+                        (BNL+CARN)
BERLINGH  69 PRL 23 42            BERLINGHIERI,FARBER,+                   (ROCH)
DONALD    69 NP B 11 551          +EDWARDS,BURAN,BETTINI,+   (LIVP+OSLO+PADO)
FAYOLLE   69 NP B 13 40           +DE MONTAIGNAC,MORAND,STRACHMAN+      (PARIS)
JUHALA    69 PR 184  1461         +LEACOCK,RHODE,KOPELMAN,LIBBY,+  (ISU+COLO)
KENYON    69 PRL 23 146           +KINSON,SCARR,+                (BNL+UCND+ORNL)

ARMENISE  70 LNC 4  199           +GHIDINI,FORING,CARTACCI,+ (BARI+BGNA+FIRZ)
ASCOLI    70 PRL 25 962           +BROCKWAY,CRAWLEY,EISENSTEIN,HANFT,+  (ILL)  JP
BRANDENB  70 NP B16 369           +BRENNER,IOFFREDO,JOHNSON,KIM+    (HARVARD)
CASO      70 LNC 3  707           +CORDS,COSTA+      (GENO+DESY+HAMB+MILA+SACL)
CRENNELL  70 PRL 24 781           +KARSHON,LAI,SCARR,SIMS                  (BNL)
GARELICK  70 PHILAD.CONF.P.205 D.A.GARELICK,REVIEW              (NORTHEASTERN)
RABIN     70 PRL 24 925           +GALTIERI,DERENZO,FLATTE,FRIEDMAN+      (LRL)

ASCOLI    71 PRL 26 929           ILLINOIS+GENO+HAMB+MIL+SACL+HARV+TNTO+WISC
BEMPORAD  71 NP B 33 397          +BEUSCH,MELISSINOS,+    (CERN+ETH+LOIC+MILA)
BERGER    71 PHENOMENOLOGY  IN PARTICLE PHYSICS, CALTECH 1971           (LRL)
RINAUDO   71 NC 5 A 239           +BOECKMANN,MAJOR+(TORI+BONN+DURH+NIJM+EPOL) JP

BERENYI   72 NP B 37 621          +PRENTICE,STEENBERG,YOON,WALKER (TNTO+WISC)
BLOODWOR  72 NP B 46 402          BLOODWORTH,JACKSON,PRENTICE,YOON  (TORONTO)
DIEBOLD   72 BATAV.CONF.3P.17 R.DIEBOLD  RAPPORTEUR TALK                 (ANL)
LAMSA     72 NP B 41 388          +EZELL,GAIDOS,WILLMANN                (PURDUE)
MORSE     72 NP B 43 77           +OH,WALKER,JOHNSTON,YOON           (WISC+TNTO)

ANTIPOV1  73 NP B 63 153          +ASCOLI,BUSNELLO,FOCACCI,+       (CERN+SERP)  JP
ANTIPOV2  73 NP B 63 141          +ASCOLI,BUSNELLO,FOCACCI,+       (CERN+SERP)  JP
ARNOLD    73 NC 17 A 393          +ENGEL,ESCOUBES,GEMESY,JANOSSY,+(STRB+BUDA)
ASCOLI 1  73 PR D 8 3894          +JONES,WEINSTEIN,WYLD                    (ILL)
ASCOLI 2  73 PRL 31 795           +CHAPIN,CUTLER,HOLLOWAY,KOESTER,KRUSE+(ILL)  JP
ATHERTON  73 PL 43 B 249          +FRANEK,FRENCH,GHIDINI,HILPERT,+        (CERN)
READ      73 NP B 64 511          B.J.READ                                (DESY)

ASCOLI    74 PR D9 1963           +CUTLER,JONES,KRUSE,ROBERTS,WEINSTEIN+(ILL)
BOWLER    74 NP B74 493           +DAINTON,KADDOURA,AITCHISON              (OXF)
KRUSE     74 PRL 32 1328          +ROBERTS,EDELSTEIN+     (ILL+CARN+NWES+ROCH)  JP
LICHTMAN  74 NP B81 31            +BISWAS,CASON,KENNEY,MCGAHAN,+          (NDAM)  JP
OTTER     74 NP B80 1             +RUDOLPH+          (AACH+BERL+BONN+CERN+HEID)  JP
TABAK     74 BOSTON CONF. P.46 +RONAT,ROSENFELD,LASINSKI+          (LBL+SLAC)  JP
THOMPSO1  74 PR D9 560            THOMPSON,GAIDOS,MCILWAIN,WILLMANN       (PURD)  JP
THOMPSO2  74 NP B69 381           THOMPSON,BADEWITZ,GAIDOS,MCILWAIN+      (PURD)  JP

ABASHIAN  75 PRL 34 691           +BEAMER,BROSS,EISENSTEIN,+      (ILL+ANL+ISU)
AITCHISO  75 PL 59 B 288          I.J.R.AITCHISON, R.J.GOLDING          (OXFORD)
ASCOLI    75 PR D 12 43           G.ASCOLI, H.W.WYLD                  (ILLINOIS)
BEUSCH    75 PL 55B 97            +POLGAR,FREUDENREICH+  (CERN+ETH+LOIC+MILA)
BOSETTI   75 NP B 101 304         +OTTER+(AACH+BERL+BONN+CERN+HEID+LOIC+WIEN)
BOWLER    75 NP B97 227           +GAME,AITCHISON,DAINTON             (OXF+DARE)
DIAZ      75 PR 12 D 1272         +DIBIANCA,FICKINGER,DADO,ENGLER+(CASE+CARN)  JP
EMMS 1    75 NP B93 1             +JONES,KINSON,BELL,DALE+   (BIRM+DURH+RHEL)  JP
EMMS 2    75 PL 60 B 109          +JONES,KINSON,BELL,DALE+   (BIRM+DURH+RHEL)  JP
HORNE     75 PR D11 996           +S.HAGOPIAN,V.HAGOPIAN,BENSINGER+(FSU+BRAN)
KANE      75  TENTH RENCONTRE DE MORIOND                                 (MICH)
WAGNER    75 PL 58B 201           +TABAK,CHEW                              (LBL)  JP

BAUBILLI  76 NP B 115 237         BAUBILLIER,RIVOAL,ARMENISE +     (BARI+LPNP)  JP
BENZ      76 NP B 115 385         +BRAUN +(AACHEN+BONN+HAMBURG+HEIDBERG+MPIM)
BRAYSHAW  76 PRL 36 73            D.BRAYSHAW                              (SLAC)

BALTAY    77 PRL 39 591           +CAUTIS,KALELKAR                   (COLUMBIA)  JP
BASDEVAN  77 PR D 16 657          BASDEVANT,BERGER                   (FNAL+ANL)  JP
CAUTIS    77  THESIS NEVIS 221 C.V.CAUTIS                            (COLUMBIA)  JP
CERRADA   77 NP B 126 241         +BLOCKZIJL,HEINEN+      (AMST+CERN+NIJM+OXF)  JP
FERRER    77  THESIS,LAL 1295  A.FERRER SORIA                          (ORSAY)
GAVILLET  77 PL 69 B 119          +BLOCKZIJL,ENGELEN+     (AMST+CERN+NIJM+OXF)  JP
HABER     77 NP B 129 429         H.E.HABER,G.L.KANE        (UNIV. OF MICHIGAN)
LONGACRE  77 PRL 38 1509          +AARON                 (NORTHEASTERN,BOSTON)  JP
SCHULT    77 PR D 16 62           + WYLD                             (ILLINOIS)  JP

ALEXANDE  78 PL 73 B 99           ALEXANDER,KNIES,+(DESY+AACH+HAMB+SIEG+WUPG)
BALTAY    78 PR D 17 62           +CAUTIS,COHEN,CSORNA,KALELKAR+  (COLU+BING)
BASDEVAN  78 PRL 40 994           BASDEVANT,BERGER                   (FNAL+ANL)  JP
CORDEN    78 NP B 136 77          DOWELL,GARVEY,JOBES+  (BIRM+RHEL+TELA+LOWC)  JP
FERRER 1  78 PL 74 B 287          +TREILLE,RIVET +        (ORSAY+CERN+CDEF+LPNP)
FERRER 2  78 NPB 142 77           +TREILLE,RIVET +        (ORSAY+CERN+CDEF+LPNP)
JAROS     78 PRL 40 1120          +ABRAMS,ALAM+           (SLAC+LBL+NWES+HAWA)
PERNEGR   78 NP B 134 436         +AEBISCHER+             (ETH+CERN+LOIC+MILA)  JP
ROBERTS   78 PR D 18 59           +KRUSE,EDELSTEIN+       (ILL+CARN+NWES+ROCH)  JP

CORDIER   79 PL B 81 389          +DELCOURT,ESCHSTRUTH,FULDA,+            (LALO)
KASPER    79 NP B 156 207         +CHAPMAN,DEROACH,GOLD,KLEIN,MARTIN+  (MELB)
MAZZUCAT  79 NP B 156 532         MAZZUCATO,PENNINGTON+  (CERN+ZEEM+NIJM+OXF)
WAGNER    79  DESY-79-66          +ALEXANDER+         (AACH+DESY+HAMB+SIEG+WUPP)

DAUM      80 PL 89 B 281          +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)  JP
DIONISI   80  CERN/EP 80-1        +GAVILLET,ARMENTEROS+ (CERN+MADR+CDEF+STOH)

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B(1235)

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11  B(1235,JPG=1++) I=1
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                   11  B MASS (MEV)

M        60(1220.0)                     ABOLINS   63 HBC  +   3.5 PI+P
M          (1220.0)                     GOLDHABER 65 HBC      3.7 PI+,PI-P
M       376 1200.       20.             BALTAY    67 HBC  +- 0.0 PBAR P          2/67
M           1259.0      27.0            BOESEBECK 68 HBC  +   8.0 PI+ P         10/67
M           1220.       20.             CHUNG     68 HBC   - 3.2,4.2 PI- P       9/67
M           1240.0      20.0            ANDERSON  70 CNTR  0 5-18 GAMMA P       11/70
M          (1272.0)    (15.0)           CASON     70 HBC   -  8.0 PI-P,4PI
M           1200.0     (10.0)           EROFEEV   70 HBC   -  3.25 PI- P         1/71
M           1225.0      22.0            HONES     70 HBC  +  18.5 PI+ P         11/70
M           1236.0      15.0            HOOGLAND  70 DBC   -  3.0 K- D           2/71
M           1200.0      15.0            MIYASHITA 70 HBC   -  6.7 PI-P,4PI
M  P       (1230.)     (10.)            POLS      70 HBC  +  5. PI+ P           11/71
M  W       (1228.)     (5.)             FRENKIEL  72 HBC  +- 0. PBAR PI,5 PI    12/72
M O  1163 1243.         6.              OTT       72 HBC  +  7.1 PI+ P,P B+      2/73
M  A       (1252.)     (6.)             OTT       72 HBC  +  7.1 PI+ P,P B+      2/73
M           1235.       15.             AFZAL     73 HBC  +  11.7 PI+ P          2/73
M           1268.       16.             AFZAL     73 HBC  -  11.2 PI- P          2/73
M      1400 1222.        4.             CHALOUPKA 74 HBC   - 3.9 PI-P,P B-      12/75
M       600 1220.        7.             KARSHON   74 HBC  +  4.9 PI+P,P B+      12/75
M       890 1245.0      11.0            FLATTE    76 HBC   - 4.2 K-P,PI-OMEGA    7/77
M       450 1251.0       8.0            GESSAROLI 77 HBC   - 11 PI-P,PI- OME    12/77
M       225 1240.0      15.0            BALTAY    78 HBC  +  15 PI+P,P 4PI       4/78*
M       360 1208.0      18.0            GAVILLET  78 HBC  +  4.2 K-P,BACKWARD    4/78*
M       105(1234.0)    (15.0)           BAUBILLIE 79 HBC   - 8.2 K- P,Y*+ B-    12/79*
M           . . . . . . . . . .
M  AVG      1230.6       3.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
M  STUDENT1230.3         3.7     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )

M   A   FROM FIT OF MASS SPECTRUM AND MOMENTS DISTRIBUTION WITH A STRONG
M   A   INTERFERENCE WITH THE BACKGROUND.
M  O    FROM FIT OF THE MASS SPECTRUM
M   P   HANDDRAWN BACKGROUND.ERRORS STATISTICAL ONLY.
M   W   FIT REQUIRES AN ADDITIONAL JP=1- RESONANCE
M   W   AT 1256 MEV, WIDTH 129 MEV.
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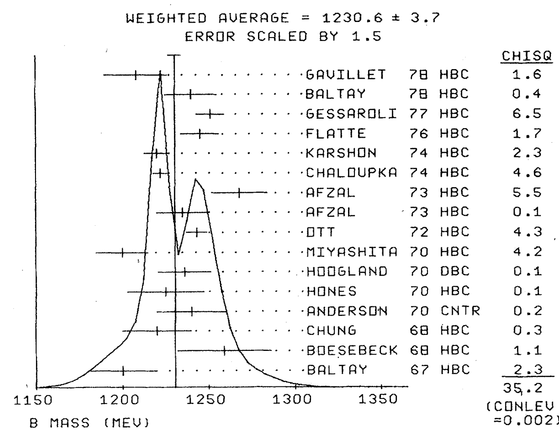


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                   11  B WIDTH (MEV)

W        60  100.0      20.0                 ABOLINS   63 HBC  +   3.5 PI+P
W           (80.0)                           GOLDHABER 65 HBC      3.7 PI+,PI-P
W       376  100.       30.                  BALTAY    67 HBC  +- 0.0 PBAR P          2/67
W        25 (100.)    ESTIMATED              LEE       67 HBC  -   3.6 PI- P          1/68
W            203.       75.                  BOESEBECK 68 HBC  +   8. PI+ P          11/67
W            150.       20.                  CHUNG     68 HBC  - 3.2,4.2 PI- P        9/67
W           (100.0)   APPROX.                ANDERSON  70 CNTR  0 5-18+GAMMA P       11/70
W           (122.0)   (38.0)     (28.0)      CASON     70 HBC  -   8.0 PI-P,4PI
W            100.0     20.0                  EROFEEV   70 HBC  -   3.25 PI- P         1/71
W             78.0     14.0      46.0        HONES     70 HBC  +  18.5 PI+ P         11/70
W            132.0     20.0                  HOOGLAND  70 DBC  -   3.0 K- D           2/71
W            113.0     44.0                  MIYASHITA 70 HBC  -   6.7 PI-P,4PI
W  P        (120.)    (20.)                  POLS      70 HBC  +  5. PI+ P           11/71
W  W        (126.)    (10.)                  FRENKIEL  72 HBC  +- 0. PBAR PI,5 PI    12/72
W O  1163    134.      23.       26.         OTT       72 HBC  +  7.1 PI+ P,P B+      2/73
W  A        (156.)    (21.)     (18.)        OTT       72 HBC  +  7.1 PI+ P,P B+      2/73
W            120.      50.                   AFZAL     73 HBC  +  11.7 PI+ P          2/73
W            130.      50.                   AFZAL     73 HBC  -  11.2 PI- P          2/73
W      1400  135.      20.                   CHALOUPKA 74 HBC  - 3.9 PI-P,P B-       12/75
W       600  156.      22.                   KARSHON   74 HBC  +  4.9 PI+P,P B+      12/75
W       890  182.0     45.0                  FLATTE    76 HBC  - 4.2 K-P,PI-OMEGA     7/77
W       450  155.0     32.0                  GESSAROLI 77 HBC  - 11 PI-P,PI- OME     12/77
W       225  170.0     50.0                  BALTAY    78 HBC  +  15 PI+P,P 4PI       4/78*
W       105 (150.0)   (50.0)                 BAUBILLIE 79 HBC  - 8.2 K- P,Y*+ B-     12/79*
W       360  163.0     50.8                  GAVILLET  78 HBC  +  4.2 K-P,BACKWARD    4/78*
W            . . . . . . . . . .
W  AVG       128.5      6.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W  STUDENT   129.3      8.0     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W   A   SEE NOTE UNDER THE MASS ABOVE.
W  O    FROM FIT OF THE MASS SPECTRUM
W   P   HANDDRAWN BACKGROUND.ERRORS STATISTICAL ONLY.
W   W   SEE NOTE UNDER THE MASS ABOVE.
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Data Card Listings

For notation, see key at front of Listings.

Mesons

B(1235), ρ′(1250), f(1270)

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                  11  B PARTIAL DECAY MODES

                                                    DECAY MASSES
P1      B INTC OMEGA+PI                             782+ 139
P2      B INTO 2PI+ 2PI-                            139+ 139+ 139+ 139
P3      B INTO K KBAR                               493+ 493
P4      B INTO PI PI                                139+ 139
P5      B INTO PI PHI                               134+1019
P6      B INTO ETA PI (FORBIDDEN BY G)              548+ 139
P7      B INTO K KBAR PI                            493+ 493+ 139

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                  11  B BRANCHING RATIOS

R10     D/S RATIO FOR B(1235) INTO OMEGA PI
R10
R10          0.3       0.1              CHALOUPKA 74 HBC  - 3.9-7.5 PI-P       1/74
R10     600  0.35      0.25             KARSHON   74 HBC  + 4.9 PI+P,P B+     12/75
R10          0.21      0.08             CHUNG     75 HBC  + 7.1 PI+P          12/75
R10          0.4       0.1        0.1   GESSAROLI 77  HBC - 11 PI-P,PI- OME   12/77
R10          . . . . . . . . . .
R10 AVG      0.291     0.052     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R10 STUDENT  0.291     0.060     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R1      B INTO (4PI)/(OMEGA PI)                            (P2)/(P1)
R1             (0.5)  OR LESS           ABOLINS   63 HBC  +   3.5 PI+P

R2      B INTO (K KBAR)/(OMEGA PI)                         (P3)/(P1)
R2             (0.02) OR LESS           DAHL      67 HBC  -   1.6-4.2 PI- P   10/66
R2             (0.10) OR LESS  CL=.90   BALTAY    67 HBC  +-  0.0 PBAR P       2/67
R2             (0.08) OR LESS  CL=.95   BIZZARRI  69 HBC  +-  0 PBAR P         9/69

R3      B INTO (PI PI)/(PI OMEGA)                          (P4)/(P1)
R3             (0.3)  OR LESS           ADERHOLZ  64 HBC      4.0 PI+P         7/66
R3             (0.15) OR LESS  CL=.90   OTT       72 HBC  +  7.1 PI+ P        12/72

R4      B INTO (PI PHI) / (PI OMEGA)                       (P5)/(P1)
R4             (0.015)OR LESS           DAHL      67 HBC      1.6-4.2 PI- P   10/66
R4             (0.04) OR LESS  CL=.95   BIZZARRI  69 HBC  +-  0 PBAR P         9/69

R5      B INTO (ETA PI) / (PI OMEGA)                       (P6)/(P1)
R5             (0.25) OR LESS  CL=.90   BALTAY    67 HBC  +-  0.0 PBAR P       2/67

R6      B+- INTO ((K KBAR)+- PIO) / (PI OMEGA)
R6             (0.08) OR LESS  CL=.90   BALTAY    67 HBC  +-  0.0 PBAR P       2/67

R6      B+- INTO (KS KS PI+-) / (PI OMEGA)
R6             (0.02) OR LESS  CL=.90   BALTAY    67 HBC  +-  0.0 PBA- P       2/67

R6      B+- INTO (KS KL PI+-) / (PI OMEGA)
R6             (0.06) OR LESS  CL=.90   BALTAY    67 HBC  +-  0.0 PBAR P       2/67

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                              REFERENCES FOR B(1235)

ABOLINS   63 PRL 11 381       ABOLINS,LANDER,MEHLHOP,XUONG,YAGER    (UCSD)
BCNDAR    63 PL 5 209         BONDAR,DODD+    (AACHEN+BIRM+HAMB+LOIC+MPIM)

ADERHOLZ  64 PL 10 240        AACHEN+BERLIN+BIRM + BONN+HAMBUR+LOIC+MPIM
CARMONY   64 PRL 12 254       CARMONY,LANDER,RINDFLEISCH,XUONG,YAGER(UCB) JP

GCLDHABE  65 PRL 15 118       G GOLDHABER,S GOLDHABER,KADYK,SHEN      (LRL)

BALTAY    67 PRL 18 93        +SEVERIENS+YEH+ZANELLO              (COLU+BNL)
DAHL      67 PR 163 1377      +HARDY+HESS+KIRZ+MILLER                 (LRL)
LEE       67 PR 159 1156      +MOEBS,ROE,SINCLAIR,VANDERVELDE        (MICH)
SLATTERY  67 NC 50A 377       +KRAYBILL+FCRMAN+FERBEL            (YALE+RCCH)

ASCOLI    68 PRL 20 1411      +CRAWLEY,MORTARA,SHAPIRO                (ILL)  JP
BOESEBEC  68 NP B 4 501       BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO      68 NC 54 A 983      +CONTE+CORDS+DIAZ+  (GENOVA+HAMB+MILA+SACL)
CHUNG     68 PR 165 1491      S.U.CHUNG,O.DAHL,J.KIRZ,D.H.MILLER      (LRL)

BIZZARRI  69 NP B 14 169      +FOSTER,GAVILLET,MONTANET,+        (CERN+CDEF)

ANDERSON  70 PR D 1 27        +GUSTAVSCN,JOHNSON,+     (SLAC+CIT+UCSB+NEAS)
CASO      70 LNC 3 707        +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
CASCN     70 PR D 1 851       +ANDREWS,BISWAS,GROVES,HARRINGTON,+    (NDAM)
EROFEEV   70 SJNP 11 450      +VETLITSKY,WLADIMIRSKY,GRIGOREV,+      (ITEP)
HONES     70 PR D 2 827       +CASON,BISWAS,HELLAND,KENNEY,MCGAHAN+(NDAM)
HOCGLAND  70 PL 33 B 631      SABRE COLLABOR.  (AMST+SACL+BGNA+REHO+EPOL)
MIYASHIT  70 PR D 1 771       MIYASHITA,VCN KRCGH,KOPELMAN,LIBBY     (COLO)
POLS      70 NP B 25 109      +BOECKMANN,CIRBA,+      (BONN+DURH+EPOL+TORI)
WERBROUC  70 LNC 4 1267       WERBROUCK,RINAUDO,+      (TORI+NIJM+BONN+LBL)JP

DEVCNS    71 PRL 27 1614      +KOZLOWSKI,HORWITZ,+               (COLU+SYRA)

FRENKIEL  72 NP B 47 61       +GHESQUIERE,LILLESTOL,CHUNG,+      (CDEF+CERN)JP
OTT       72  LBL-1547        R.L.OTT  THESIS                         (LBL)JP
SISTERSO  72 NP B 48 493      SISTERSON,HARRISON,HEYDA,JOHNSON,+(HARVARD)

AFZAL     73 NCL 15 A 61      +BASSLER,+        (DURH+GENO+DESY+MILA+SACL)  JP
ARMENISE  73 NC 17 A 707      +FORINO,CARTACCI,+            (BARI+BGNA+FIRZ)
ARMENISE  73 LNC 8 425        +FORINO,CARTACCI,+            (BARI+BGNA+FIRZ)
ARNOLD    73 LNC 6 707        +ENGEL,ESCOUBES,KURTZ,LLORET,PATY,+    (STRB)
CASCN     73 PR D 7 1971      +BISWAS,KENNEY,MADDEN,SANDER,SHEPHARD(NDAM)
CASON 1   73 NP B 64 14       +MADDEN,BISHCP,BISWAS,KENNEY,+         (NDAM)
COHEN     73 PR D 8 23        +FERBEL,SLATTERY                  (ROCHESTER)

BALLAM    74 NP B76 375       +CHADWICK,BINGHAM,FRETTER+  (SLAC+LBL+MPIM)
CHALCUPK  74 PL 51B 407       CHALOUPKA,FERRANDO,LOSTY,MONTANET      (CERN)  JP
KARSHCN   74 PR D10 3608      +MIKENBERG,EISENBERG,PITLUCK,RCNAT+   (REHO)  JP

CHUNG     75 PR D11 2426      +PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)  JP
    ALSO  73 PL 47 B 526      +PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)  JP
DUBOVIKO  75 SJNP 20 229      M.S.DUBOVIKCV,I.A.EROFEEV              (ITEP)  JP

FLATTE    76 PL 64 B 225      +GAY,BLOKZIJL,METZGER,+(CERN+AMST+NIJM+CXF)  JP

GESSAROL  77 NP B 126 382     GESSAROLI,+  (BGNA+FIRZ+GENO+MILA+OXF+PAVI)  JP

BALTAY    78 PR D 17 62       +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
GAVILLET  78 PL 78 B 158      +DIONISI,GURTU,+          (CERN+AMST,NIJM+CXF)  JP

BAUBILLI  79  CERN/EP 79-72   BAUBILLIER,+        (BIRM+CERN+GLAS+MSU+LFNP)

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ρ′(1250)

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69  RHO PRIME(1250,JPG=1-+) I=1

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.
SEE ALSO THE RHO PRIME(1600) MINI-REVIEW.

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                  69  RHO PRIME(1250) MASS   (MEV)

M          1256.      10.              FRENKIEL  72 HBC  +- 0.PBARP,OMEGA2PI 12/77
M          1266.0      5.0             BARTALUCC 79 MASP   07 GAM P,E+E- P   12/79*
M          . . . . . . . . . .
M   AVG    1264.0      4.5      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1264.1      5.0      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                  69  RHO PRIME(1250) WIDTH  (MEV)

W           130.      20.              FRENKIEL  72 HBC  +- 0.PBARP,OMEGA2PI 12/77
W           110.0     35.0             BARTALUCC 79 MASP   07 GAM P,E+E- P   12/79*
W          . . . . . . . . . .
W   AVG     125.1     17.4      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W   STUDENT 125.1     18.8      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                              REFERENCES FOR RHO PRIME(1250)

ANDERSON 70 PR D 1 27          +GUSTAVSON,JOHNSON,+    (SLAC+CIT+UCSB+NEAS)
PODOLSKY 71  UCRL 20128        W.J.PODOLSKY,PH.D. THESIS              (LBL)
FRENKIEL 72 NP B 47 61         +GHESQUIERE,LILLESTOL,CHUNG,+    (CDEF+CERN)JP
WOLF     72 ITHACA N.Y. CONF.  G.WOLF,P.213                          (SLAC)

CHUNG    73 PL 47 B 526        +PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)
BRAMON   73 LNC 8 659          A.BRAMON                          (FRASCATI)

BALLAM   74 NP B76 375         +CHADWICK,BINGHAM,FRETTER+  (SLAC+LBL+MPIM)
CHALOUPK 74 PL 51B 407         CHALOUPKA,FERRANDO,LOSTY,MONTANET     (CERN)
CCNVERSI 74 PL 52B 493         +PAOLUZI,CERADINI,GRILLI+        (ROMA+FRAS)
ESTABROO 74 NP B79 301         P.ESTABROOKS,A.D.MARTIN               (DLRH)
KARSHON  74 PR D10 3608        +MIKENBERG,EISENBERG,PITLUCK,RONAT+  (REHO)  JP

ALLES    75 NC 30A 136         ALLES-BORELLI,BERNARDINI+  (CERN+BGNA+FRAS)
CHUNG    75 PR D11 2426        +PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)
ESTABROO 75 NP B95 322         P.ESTABROOKS,A.D.MARTIN               (DURH)
FROGGATT 75 NP B91 454         C.D.FROGGATT,J.L.PETERSEN        (GLAS+NORD)
HYAMS    75 NP B100 205        +JONES,WEILHAMMER,BLUM,DIETL+    (CERN+MPIM)

BASSOMPI 76 PL 65 B 397        BASSOMPIERRE,BINDER,+        (MULH+STRB+TORI)

BUDNEV   77 PL 70 B 365        N.M.BUDNEV,V.M.BUDNEV,V.V.SEREBRYAKOV(NOVO)
COSTA    77 PL 67 B 213        COSTA DE BEAUREGARD,PHAM,PIRE,TRUONG (EPOL)
GESSAROL 77 NP B 126 382       GESSAROLI,+  (BGNA+FIRZ+GENO+MILA+OXF+PAVI)

BUKIN    78 PL  73 B 226       +VASSERMAN,KOOP,KURDADZE,SIDOROV,+    (NCVO)

BACCI    79 PL B 86 234        +DE ZORZI,PENSO,STELLA,+    (ROMA+BGNA+FRAS)
BARTALUC 79 NC 49 A 207        BARTALUCCI,BASINI,BERTOLUCCI+    (DESY+FRAS)

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f(1270)

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5  F(1270,JPG=2++) I=0

WE NO LONGER LIST EVERY PUBLISHED VALUE.
WE AVERAGE CNLY THE MOST SIGNIFICANT
DETERMINATIONS OF MASS AND WIDTH.

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                  5  F MASS (MEV)

M           (1250.0)    (25.0)            SELOVE    62 HBC    3.0 PI- P          1/73
M       1416(1267.0)    (10.0)            JACOBS    66 HBC    2-3 PI-P,T CUT20  10/67
M            1276.       11.              RABIN     67 HBC    8.5 PI+ P          9/67
M   T   1960 1261.        5.              ARMENISE  68 DBC    5.1 PI+N,P PI+ -   1/73
M   T    360 1270.       10.              ARMENISE  68 DBC    5.1 PI+N,P PIO 0   1/73
M            1265.        8.              BOESEBECK 68 HBC    8 PI+ P            6/68
M     J      1268.0       6.0             JOHNSON   68 HBC     3.7-4.2 PI- P     7/69
M            1275.0      13.0             ARMENISE  70 HBC     9 PI+ N -- F P    1/71
M            1273.0       7.0             ARMENISE  70 HBC     9 PI+ N -- MM P   1/71
M        600 1275.0      10.0             OH        70 HBC    1.26 PI- P,P F     1/71
M   E       (1273.0)     (6.0)            STUNTEBEC 70 HBC    8.PI-P,5.4 PI+D   11/71
M       5300 1277.0       4.0             FLATTE    71 HBC     7.0 PI+ P         6/71
M   E    300(1272.)                       KEMP      72 DBC    11.7 PI+ N        12/72
M       2000 1261.0      10.0             JACOBS    72 HBC     2.8 PI- P         1/73
M        600 1258.0      10.0             TAKAHASHI 72 HBC    8. PI- P,N 2PI     1/73
M       1200 1274.       12.              WHITEHEAD 72 ASPK   3.1-3.6 PI- P   .  2/73
M       4600 1272.        4.              ENGLER    74 DBC     6. PI+N,PI+PI-P  12/75
M   IH      (1269.)      (4.)             ESTABROOK 75 RVUE   17 PI-P,PI+PI-N   12/75
M   IG      (1275.)      (4.)             HYAMS     75 ASPK    17 PI-P,PI+PI-N  12/75
M      16000 1284.0      10.0             DEUTSCHMA 76 HBC    16 PI+P            4/78*
M            1273.8       2.8      2.7    BECKER    79 ASPK   17 PI- P POLARIZ  12/79*
M            1282.0       5.0             CORDEN    79 OMEG   12-15PI-P, N 2PI  12/79*
M            . . . . . . . . . .
M    AVG     1272.5       1.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
M    STUDENT1272.7        1.7     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M   E    EVIDENCE FOR A STRUCTURE CLAIMED
M    G   INCLUDED IN BECKER 79 ANALYSIS
M    H   USES SAME CATA AS HYAMS 75
M   I    ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTICNS
M     J  JOHNSCN 68 INCLUDES BONDAR 63, LEE 64, DERADO 65, EISNER 67.
M   T    MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K* TYPED NOTE

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                  5  F WIDTH (MEV)

W           (100.0)    (25.0)             SELOVE    62 HBC     3.0 PI-P
W      1416  (99.0)    (10.0+             JACOBS    66 HBC    2-3 PI-P,T CUT20  10/67
W             155.      17.               RABIN     67 HBC    8.5 PI+ P          9/67
W   T  1960   216.      20.               ARMENISE  68 DBC    5.1 PI+N,P PI+ -   1/73
W    T  360  (188.)    (40.)              ARMENISE  68 DBC    5.1 PI+N,P PIO 0   1/73
W             128.      23.               BOESEBECK 68 HBC    8 PI+ P            6/68
W     J       176.0     13.0              JOHNSON   68 HBC     3.7-4.2 PI- P     7/69
W             131.0     25.0              ARMENISE  70 HBC     9 PI+ N -- MM P   1/71
W   T         173.0     25.0              ARMENISE  70 HBC     9 PI+ N -- F P    2/74
W   T   600   120.0     20.0              OH        70 HBC    1.26 PI- P,P F     2/74
W    E       (196.0)   (18.0)             STUNTEBEC 70 HBC    8.PI-P,5.4 PI+D   11/71
W      5300   183.0     15.0              FLATTE    71 HBC    7.PI+P,DELTA++F    1/71
W   E   300  (143.)                       KEMP      72 DBC    11.7 PI+ N        12/72
W      2000   130.0     25.0              JACOBS    72 HBC     2.8 PI- P         1/73
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Mesons

f(1270)


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W  T    600  166.0     28.0               TAKAHASHI 72 HBC     8. PI- P,N 2PI     1/73
W      1200 (217.)    (24.)               WHITEHEAD 72 ASPK    3.1-3.6 PI- P    . 2/73
W      4600  192.      16.                ENGLER    74 DBC      6. PI+N,PI+P+-P 12/75
W  IH       (209.)    (10.)               ESTABROOK 75 RVUE    17 PI-P,PI+PI-N  12/75
W  IG       (188.)     (4.)               HYAMS     75 ASPK     17 PI-P,PI+PI-N 12/75
W     16000  225.0     38.0               DEUTSCHMA 76 HBC     16 PI+P            4/78*
W            183.2      8.3      7.9      BECKER    79 ASPK    17 PI- P PCLARIZ 12/79*
W            216.0     13.0               CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79*
W             . . . . . . . . .
W   AVG      178.0      7.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
W   STUDENT  178.3      5.5     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )

W  E     EVIDENCE FOR A STRUCTURE CLAIMED
W   G    INCLUDED IN BECKER 79 ANALYSIS
W   H    USES SAME CATA AS HYAMS 75
W  I     ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
W     J  JOHNSON 68 INCLUDES BONDAR 63, LEE 64, DERADO 65, EISNER 67.
W  T     WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE
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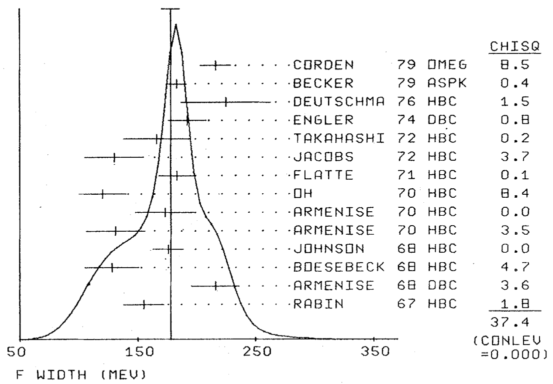
WEIGHTED AVERAGE = 178.0 ± 7.4
ERROR SCALED BY 1.7

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                    5  F PARTIAL DECAY MODES

                                                           DECAY MASSES
P1     F INTO PI PI                                      139+ 139
P2     F INTO 2PI+ 2PI-                                  139+ 139+ 139+ 139
P3     F INTO PI+ PI- 2PIO                               139+ 139+ 134+ 134
P4     F INTO K KBAR                                     497+ 497
P5     F INTO K KBAR PI                                  497+ 497+ 139
P6     F INTO ETA PI PI                                  548+ 139+ 139
P7     F INTO ETA ETA                                    548+ 548
P8     F INTO GAMMA GAMMA                                  0+   0

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                    5  F PARTIAL WIDTHS

W1     F INTO GAMMA GAMMA (KEV)                                            12/78*
W1          (24.0)  OR LESS CL=0.95   ABRAMS    79 SMAG    E+ E-           12/79*

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                    5  F BRANCHING RATIOS

R1     F INTO (2PI+ 2PI-)/(PI PI)                              (P2)/(P1)
R1    ASCOLI 68 SUGGEST DECAY IS MAINLY RHO-RHO,1/3 OF WHICH YIELD 2PI+ 2PI-
R1            0.08      0.06              BONDAR    63 HBC     4.0 PI-P
R1    D       0.04      0.05              CHUNG     65 HBC     3.2 PI-P         11/71
R1    D  CORRECTED BY O.DAHL                                                    11/71
R1      50    0.07      0.04              ASCOLI    68 HBC     5 PI- P           6/68
R1            0.022     0.045     0.022 BARDADIN   71 HBC     8. PI+ P           2/72
R1            0.047     0.013             OH        70 HBC     1.26 PI- P,P F    2/73
R1     154    0.037     0.007             ANDERSCN  73 DBC     6. PI+N,P FO      1/74
R1           (0.033)OR LESS  C.L.=.90 BUGG      73 DBC     8. PI+N,P FO      1/74
R1      70    .051      .025              EISENBERG 74 HBC     4.9 PI+P,DEL++FO 11/75
R1     285    .043      .007      .011 LOUIE     74 HBC     3.9 PI- P,N FO  .11/75
R1     160    .024      .006              EMMS      75 DBC     4.  PI+N,P FO    11/75
R1             . . . . . . . . .
R1   AVG      0.0344    0.0040  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R1   STUDENT  0.0351    0.0047  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R2     F INTO (PI+ PI- 2PIO)/(PI PI)                           (P3)/(P1)
R2    SHOULD BE TWICE R1 IF DECAY IS RHO-RHO (SEE ASCOLI 68)
R2     600    .15       .06               EISENBERG 74 HBC     4.9 PI+P,DEL++FO 11/75
R2           (.07)                        EMMS      75 DBC     4.  PI+N,P FO    11/75

R3     F INTO (K KBAR)/(PI PI)                                 (P4)/(P1)
R3        WE ONLY AVERAGE EXPERIMENTS WHICH EITHER TAKE INTO ACCOUNT F-A2
R3        INTERFERENCE EXPLICITLY OR DEMONSTRATE THAT A2 PRODUCTION IS
R3        NEGLIGIBLE.
R3           (0.047)  (0.012)+ SYST.  BEUSCH    67 OSPK    5,7,12 PI-P        9/67
R3            0.05      0.05              DAHL      67 HBC      1.6-4.2 PI- P .10/66
R3      20    0.031     0.012             ADERHOLZ  69 HBC      8 PI+ P,K+K-PI- 12/75
R3 L         (0.07) OR LESS  CL=.95   AGUILAR   72 HBC     3.9,4.6 K- P      12/72
R3 L   LIMIT ABOVE RESTATED FOR AVERAGING BELOW.                                12/72
R3 L          0.0       0.04              AGUILAR   72 HBC     3.9,4.6 K- P      12/72
R3            0.13      0.05              BISWAS    72 HBC     18.5 PI+- P        1/73
R3           (0.02) OR LESS  CL=.85   WHITEHEAD 72 ASPK    3.1-3.6 PI- P     12/72
R3            0.03      0.02              TOET      73 HBC     5 PI+P,P PI+ FO    1/74
R3            .025      .015              EMMS      75 DBC     4.  PI+N,P FO    11/75
R3   W       (.029)    (.006)             WETZEL    76 OSPK    8.9 PI-P,KS KS     7/77
R3    C       0.047     0.005             PAWLICKI  77 SPEC    6. PI N,K+ K- N  12/77
R3    N       0.028     0.005             CASON     78 STRC    7. PI-P,KS KS N  12/78*
R3           (0.069)   (0.023)  (0.031)GORLICH   79 ASPK    17,18 PI-P POLAR 12/79*
R3           (0.039)   (0.008)            LOVERRE   79 HBC     4. PI-P,K K N    12/79*
R3            0.030     0.005             MARTIN    79 RVUE                     12/79*
R3    M       0.027     0.009             POLYCHRON 79 STRC    7. PI-P,KS KS N  12/79*
R3             . . . . . . . . .
R3   AVG      0.0339    0.0033  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R3   STUDENT  0.0323    0.0033  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )

R3    C  THIS DETERMINATION HAS QUANTITATIVELY ACCOUNTED FOR BOTH F-PRIME
R3    C  AND A2 INTERFERENCE EFFECTS.
R3    M  TAKES INTO ACCOUNT THE F-F' INTERFERENCE
R3    N  BY EXTRAPOLATION TO THE PION POLE
R3    W  USING F PRIME WIDTH = 40 MEV
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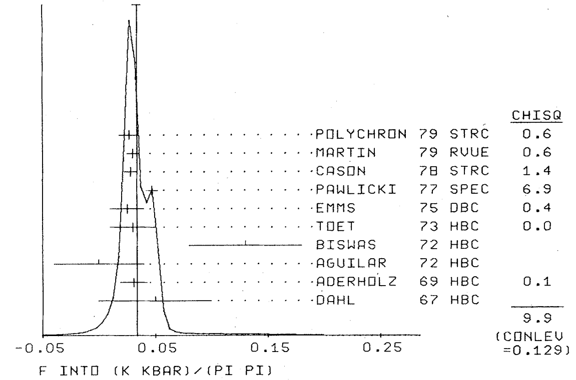
WEIGHTED AVERAGE = 0.0339 ± 0.0033
ERROR SCALED BY 1.3

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R4     F INTO (KO K- PI+ AND C.C.)/(PI PI)                     (P5)/(P1)
R4         (0.07) OR LESS  CL=.95   AGUILAR   72 HBC     3.9,4.6 K- P      12/72
R4          (.004)OR LESS  CL=.95   EMMS      75 DBC     4.  PI+N,P FO     11/75

R5     F INTO (ETA PI PI)/(PI PI)                              (P6)/(P1)
R5         (0.19) OR LESS  CL=.95   AGUILAR   72 HBC     3.9,4.6 K- P      12/72
R5          (.010)OR LESS  CL=.95   EMMS      75 DBC     4.  PI+N,P FO     11/75

R6     F INTO (ETA ETA)/(PI PI)                                (P7)/(P1)
R6          (.09) OR LESS  CL=.95   EISENBERG 74 HBC     4.9 PI+P,DEL++FO 11/75
R6          (.016)OR LESS  CL=.95   EMMS      75 DBC     4.  PI+N,P FO     11/75

R10    F INTO (PI PI)/TOTAL                                    (P1)
R10    600    0.8       0.04              OH        70 HBC     01.26 PI- P,P F     1/71
R10    250    0.85      0.05              BEAUPRE   71 HBC     08 PI+ P,DELTA++F   1/71
R10IH        (.82)     (.01)              ESTABROOK 75 RVUE     17 PI-P,PI+PI-N  12/75
R10IG        (.803)    (.003)             HYAMS     75 ASPK      17 PI-P,PI+PI-N 12/75
R10           0.847     0.016             BECKER    79 ASPK    17 PI- P PCLARIZ 12/79*
R10           0.75      0.04              CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79*
R10            . . . . . . . . .
R10 AVG       0.831     0.019   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R10 STUDENT   0.833     0.016   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                       (SEE IDEOGRAM BELOW )

R10 G   INCLUDED IN BECKER 79 ANALYSIS
R10 H   USES SAME DATA AS HYAMS 75
R10I    ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
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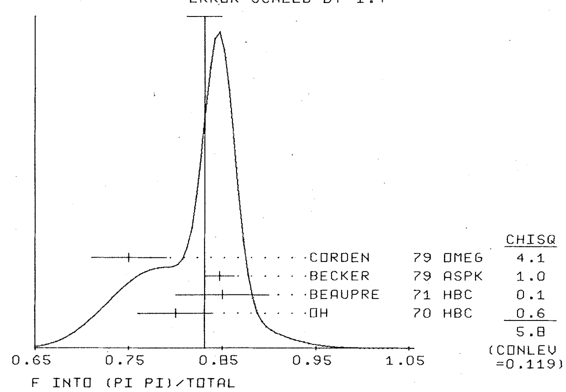
WEIGHTED AVERAGE = 0.831 ± 0.019
ERROR SCALED BY 1.4



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REFERENCES FOR F


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SELOVE    62 PRL 9 272          SELOVE,HAGOPIAN,BRODY,BAKER,LEBOY       (PENN)
BONDAR    63 PL 5 153           BONDAR+   (AACHEN+BIRM+BONN+DESY+LOIC+MPIM)
GUIRAGOS  63 PRL 11 85          Z.G.T. GUIRAGOSSIAN                      (LRL)
HAGOPIAN  63 PRL 10 533         V HAGOPIAN,W SELOVE                     (PENN)
VEILLET   63 PRL 10 29          VEILLET,HENNESSY,BINGHAM,BLOCH+(EPOL+MILAN)

ADERHOLZ  64 PL 10 240          AACHEN¬BERLIN¬BERLIN¬BONN¬HAMBURG¬LOIC¬MPI  IJ
BRUYANT   64 PL 10 232          BRUYANT,GOLDBERG,HOLDER,FLEURY+ (CERN+EPOL) I
LEE       64 PRL 12 342         LEE,ROE,SINCLAIR,VANDERVELDE            (MICH)
SODICKSO  64 PRL 12 485         SODICKSON,WAHLIG,MANNELLI,FRISCH+        (MIT) I

BARMIN    65 SJNP 1 230         +DOLGOLENKO,ELENSKY,EROFEEV+  (ITEP MOSCOW) JP
BARMIN    65 SJNP 1 623         +DOLGOLENKO+EROFEEV+KRESTNIKOV+ (ITEP MCSC)
CHUNG     65 PRL 15 325         CHUNG,DAHL,HARDY,HESS,JACOBS,KIRZ        (LRL)
DERADO    65 PRL 14 872         DERADO,KENNEY,POIRIER,SHEPHARD (NOTRE DAME)
GUIRAGOS  65 PRL 11 85          Z G T GUIRAGOSSIAN                       (LRL)
WANGLER   65 PR  137 B 414      T P WANGLER,A R ERWIN,W WALKER   (WISCONSIN)
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Data Card Listings

For notation, see key at front of Listings.

Mesons

f(1270), η(1275), D(1285)


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ACCENSI   66 PL 20 557            ACCENSI,ALLES-BORELLI,FRENCH,FRISK+  (CERN)
JACOBS    66 UCRL-16877           L.D.JACOBS,THESIS                     (LRL)
WAHLIG    66 PR  147  941         +SHIBATA,GORDON,FRISCH,MANNELLI  (MIT+PISA) J

BARLOW    67 NC 50A 701           +LILLESTOL+MONTANET+  (CERN+CDEF+IRAD+LIVP)
BEUSCH    67 PL 25 B 357          +FISCHER,GCBBI,ASTBURY+           (ETH+CERN)
DAHL      67 PR 163 1377          +HARDY+HESS+KIRZ+MILLER                (LRL)
EISNER    67 PR 164 1699          +JOHNSCN+KLEIN+PETERS+SAHNI+YEN+    (PURDUE)
POIRIER   67 PR 163 1462          +BISWAS,CASON,DERADO,KENNEY+     (NDAM+PENN)
RABIN     67 THESIS               M. RABIN                           (RUTGERS)

ARMENISE 68 NC 54 A 999           +FORINO+CARTACCI+ (BARI+BGNA+FIRENZE+ORSAY)
ASCOLI    68 PRL 21 1712          G.ASCOLI,H.B.CRAWLEY,D.W.MORTARA,+     (ILL)
BOESEBEC 68 NP B 4 501            BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
FOSTER    68 NP B 6 107           +GAVILLET+LABROSSE+MONTANET+     (CERN+CDEF)
JOHNSON   68 PR 176 1651          +POIRIER,BISWAS,GUTAY+      (NDAM+PURD+SLAC)
LAMSA     68 PR 166 1395          +CASON+BISWAS+DERADO+GROVES+     (NOTREDAME)
WHITEHEA 68 NC 53A 817            +MCEWEN,OTT,AITKEN+         (AERE+SHMP+LOUC)

ADERHOLZ 69 NP B 11 259           +BARTSCH,+        (AACH+BERL+CERN+JAGL+WARS)
AGUILAR- 69 PL 29 B  241          M.AGUILAR-BENITEZ,J.BARLOW,+     (CERN+CDEF)
ARMENISE 69 LNC 2 501             +GHIDINI,FORINO,CARTACCI+   (BARI+BGNA+FIRZ)
CASO      69 NC 62 A 755          +CONTE,BENZ,+      (GENO+DESY+HAMB+MILA+SACL)
DONALD    69 NP B 11 551          +EDWARDS,BURAN,BETTINI,+    (LIVP+OSLO+PADO)

AGUILAR   70 PRL 25 58            AGUILAR-BENITEZ,BARNES,BASSANO,+ (BNL+SYRA)
ARMENISE 70 LNC 4  199            +GHIDINI,FORING,CARTACCI,+ (BARI+BGNA+FIRZ)
BADIER    70 NP B 22 512          +BONNET,DREVILLON,BAUBILLIER,+  (EPOL+IPNP)
OH        70 PR D 1 2494          +GARFINKEL,MORSE,WALKER,PRENTICE(WISC+TNTOJ)
STUNTEBE 70 PL 32 B 391           STUNTEBECK,KENNEY,DEERY,BISWAS,CASON+(NDAM)

BARDADIN 71 PR D4 2711            BARDANIN-OTWINOWSKA,HOFMOKL,+         (WARS)
BEAUPRE   71 NP B 28 77           +DEUTSCHMANN,GRAESSLER,+    (AACH+BERL+CERN)
FARBER    71 NP B 29 237          +DE PINTO,BISWAS,CASON,DEERY,KENNEY,+(NDAM)
FLATTE    71 PL 34 B 551          +ALSTON-GARNJOST,BARBARO-GALTIERI,+    (LBL)

AGUILAR   72 PR D 6 29            AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS    (BNL)
BISWAS    72 PR D 5 1564          +CASON,HARRINGTON,KENNEY,SHEPHARD     (NDAM)
FOGLI     72 NC 8 A 670           FOGLI-MUCIACCIA,PICCIARELLI           (BARI)
GRAYER    72 PHIL.CCNF.PROC. 5 +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
JACOBS    72 PR D 6 1291          L.D.JACOBS                          (SACLAY)
KEMP      72 NC 8 A 611           +MAJOR,CONTRI,+  (DURH+GENO+MILA+EPOL+LPNP)
SCARROTT 72 LNC 3 271             SCARROTT,KEMP                       (DURHAM)
TAKAHASH 72 PR D 6 1266           TAKAHASHI,BARISH,+      (TOHO+PENN+NDAM+ANL)
WHITEHEA 72 NP B 48 365           WHITEHEAD,AULD,+            (AERE+RHEL+SHMP+LOUC)

ANDERSCN 73 PRL 31 562            +ENGLER,KRAEMER,TOAF,DIAZ,+      (CARN+CASE)
BUGG      73 PR D 7 3264          +CONDO,HART,CGHN,ENDORF,+  (TENN+ORNL+CINC)
CHARLESW 73 NP B 65 253           CHARLESWORTH,EMMS,BELL,+   (RHEL+BIRM+DURH)
HYAMS     73 NP B 64 134          +JONES,WEILHAMMER,BLUM,DIETL,+  (CERN+MPIM)
TOET      73 NP B 63 248          +THUAN,MAJOR,RINAUDO,+(NIJM+BONN+DURH+TCRI)

EISENBER 74 PL 52B 239            EISENBERG,ENGLER,HABER,KARSHON+       (REHO)
ENGLER    74 PR D10 2070          +KRAEMER,TOAFF,WEISSER,DIAZ+     (CARN+CASE)
GRAYER    74 NP B 75 189          G.GRAYER,HYAMS,BLUM,DIETL,+      (CERN+MPIM)
HOLLOWAY 74 PR D9 1161            +HULD,JORDAN,KOETZ,BERNSTEIN+     (ILL+ILLC)
LOUIE     74 PL 48B 385           +ALITTI,GANDOIS,CHALOUPKA+       (SACL+CERN)

EMMS      75 NP B96 155           +KINSON,STACEY,VOTRUBA+     (BIRM+DURH+RHEL)
ESTABROO 75 NP B95 322            P.ESTABROOKS,A.D.MARTIN               (DURH)
HYAMS     75 NP B100 205          +JONES,WEILHAMMER,BLUM,DIETL+    (CERN+MPIM)
PAWLICKI 75 PR D12 631            +AYRES,DIEBOLD,GREENE,KRAMER,WICKLUND (ANL)

DEUTSCHM 76 NP B 103 426          +KIRK,+(AACH+BERL+BONN+CERN+CRAC+HEID+WARS)
WETZEL    76 NP B 115 208         +FREUDENREICH,BEUSCH,+       (ETH+CERN+LOIC)

ALEXANDE 77 NP B 131 365          ALEXANDER,CORDEN,+      (TELA+BIRM+RHEL+LOWC)
ANTIPOV   77 NP B 119 45          +BUSNELLO,DAMGAARD,KIENZLE,+     (SERP+GEVA)
PAWLICKI 77 PR D 15 3196          +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND   (ANL)

BALTAY    78 PR D 17 62           +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
CASON     78 PRL 41 271           +BAUMBAUGH,BISHOP,BISWAS,KENNEY,+(NDAM+ANL)

ABRAMS    79  SLAC-PUB 2421       +ALAM,BLOCKER,BOYARSKI,+          (SLAC+LBL)
BECKER    79 NP B 151  46         +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN    79 NP B 157 250         +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LCWC)
GORLICH   79  CERN/EP 79-139      +NICZYPORUK,ROZANSKA+ (CRAC+MPIM+CERN+ZEEM)
LOVERRE   79  CERN/EP 79-162      +ARMENTEROS,DIONISI+  (CERN+CDEF+MADR+STOH)
MARTIN    79 NP B 158 520         +OZMUTLU                              (DURH)
POLYCHRO 79 PR D 19 1317          POLYCHRONAKOS,CASON,BISHOP+       (NDAM+ANL)

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η(1275)

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37  ETA(1275,JPG=0-+) I=0

--->  SEEN IN PHASE SHIFTS ANALYSIS OF THE ETA PI+ PI-
      SYSTEM WITH PI+ PI- IN AN S-WAVE  (STANTON 79).
      WAIT CONFIRMATICN. OMITTED FROM TABLE.

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                37  ETA(1275) MASS (MEV)

M       (1275.)   APPROX.        STANTON   79 CNTR  0 8.4PI-P,ETA 2PI  12/79*
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                37  ETA(1275) WIDTH (MEV)

W        (70.)    APPROX.        STANTCN   79 CNTR  0 8.4PI-P,ETA 2PI  12/79*
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                37  ETA(1275) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1     ETA(1275) INTO DELTA PI                      981+ 139
P2     ETA(1275) INTO ETA PI+ PI-                   548+ 139+ 139
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                37  ETA(1275) BRANCHING RATIOS.

R1     ETA(1275) INTO DELTA PI                   (P1)
R1         LARGE                 STANTCN   79 CNTR  0 8.4PI-P,ETA 2PI  12/79*
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                        REFERENCES FOR ETA(1275)
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STANTON  79 PRL 42 346        +BROCKMAN,DANKOWYCH,+  (OSU+CARL+MCGI+TNTO)  JP
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D(1285)

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8  D(1285,JPG=1++) I=0
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                8  D MASS (MEV)

M          (1290.)   APPROX.        BARLOW    67 HBC    1.2 PBAR P, 4PFS  5/67
M           1283.0     5.0          DAHL      67 HBC     1.6-4.2 PI- P   10/66
M           1290.      7.           D-ANDLAU  68 HBC 1.2 PBAR P, 5-6 PFS  6/68
M          (1310.0)                 DEFOIX    68 HBC     1.2 PB P,7 PI    3/69
M           1270.0    10.0          CAMPBELL  69 DBC     2.7 PI+ D        8/69
M           1285.      7.           LORSTAD   69 HBC 0.7 PB P, 4,5-BODY   9/69
M           1303.0     8.0          BARDADIN  71 HBC     8 PI+ P, P+6PI   9/69
M           1283.0     6.0          BOESEBECK 71 HBC    16.0 PI P,5 PI    6/71
M       150 1292.     10.           DEFOIX    72 HBC    0.7 PBAR P,7 PI   1/73
M       180 1286.      3.           DUBOC     72 HBC    1.2 PBAR P,2K4PI 12/72
M   S   500(1280.)    (3.)          THUN      72 MMS    13.4 PI- P       12/72
M       210 1279.0     5.0          GRASSLER  77 HBC    16. PI-+ P       11/77
M        85 1295.0    12.0          CORDEN    78 OMEG   12-15PI-P, N 5PI  4/78*
M        34(1271.0)  (10.0)         CORDEN    78 OMEG   12-15PI-P,K+K-PI  4/78*
M       320 1282.0     2.0          NACASCH   78 HBC    .7+.76 PB P,KKBP  4/78*
M       200 1288.0     9.0          GURTU     79 HBC    4.2 K- P,ETA 2PI 12/79*
M   P    46(1275.0)  APPROX.        STANTCN   79 CNTR   8.5PI-P,2GAM 2PI 12/79*
M       103 1283.0     3.0          DIONISI   80 HBC    4. PI- P,K KB PI 12/79*
M          . . . . . . . . . .
M   AVG     1283.8     1.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1283.7      1.4     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M   P   FROM PHASE SHIFT ANALYSIS OF ETA PI+PI- SYSTEM.
M   S   SEEN IN THE MISSING MASS SPECTRUM

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                8  D WIDTH (MEV)

W   R        (35.0)   (10.0)        DAHL      67 HBC     1.6-4.2 PI- P   11/71
W  U          46.      20.          D-ANDLAU  68 HBC 1.2 PBAR P, 5-6 PFS  2/72
W   R        (40.0)                 DEFOIX    68 HBC     1.2 PB P,7 PI   11/71
W             30.0     15.0         CAMPBELL  69 DBC     2.7 PI+ D        8/69
W   R        (60.)    (15.)         LORSTAD   69 HBC 0.7 PB P, 4,5-BODY  11/71
W   R        (44.0)   (24.0)        BARDADIN  71 HBC     8 PI+ P, P+6PI  11/71
W             10.0     10.0         BOESEBECK 71 HBC    16.0 PI P,5 PI    6/71
W   R  150   (28.)    (5.)          DEFOIX    72 HBC    0.7 PBAR P,7 P9   1/73
W   R  180   (46.)    (9.)          DUBOC     72 HBC    1.2 PBAR P,2K4PI 12/72
W   S  500   (37.)    (5.)          THUN      72 MMS    13.4 PI- P       12/72
W      210    24.0     18.0         GRASSLER  77 HBC    16. PI-+ P       12/77
W    D  85    70.0     30.0         CORDEN    78 OMEG   12-15PI-P, N 5PI  4/78*
W    D  34   (55.0)   (38.0)        CORDEN    78 OMEG   12-15PI-P,K+K-PI  4/78*
W      320    28.3      6.7         NACASCH   78 HBC    .7+.76 PB P,KKBP  4/78*
W      200    25.0     15.0         GURTU     79 HBC    4.2 K- P,ETA 2PI 12/79*
W      103    29.0     10.0         DIONISI   80 HBC    4. PI- P,K KB PI 12/79*
W   P        (10.0)  APPROX.        STANTCN   79 CNTR   8.5PI-P,2GAM 2PI 12/79*
W          . . . . . . . . . .
W   AVG       26.5      4.2    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W   STUDENT   26.8      4.7    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W   P   FROM PHASE SHIFT ANALYSIS OF ETA PI+PI- SYSTEM.
W   R   RESOLUTION NOT UNFOLDED
W   S   SEEN IN THE MISSING MASS SPECTRUM
W  U    UNFOLDED BY DOBRZYNSKI 71

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                8  D PARTIAL DECAY MODES

                                                      DECAY MASSES
P1     D INTO K KBAR PI                              497+ 497+ 134
P2     D INTO PI PI RHO                              134+ 134+ 776
P3     D INTO ETA PI PI                              548+ 134+ 134
P4     D INTO DELTA PI                               981+ 134
P5     D INTO 2PI+ 2PI-                              139+ 139+ 139+ 139
P6     D INTO K* KBAR                                892+ 497
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                8  D BRANCHING RATIOS

R1     D INTO (PI PI RHO) / (K KBAR PI)                  (P2)/(P1)
R1          (2.0)  OR LESS          DAHL      67 HBC     CHARGED PI ONLY 10/66
R1  D       (4.0)  OR LESS          DONALD    69 HBC     1.2 PBAR P,5P+ .
R1  D       THIS IS FOR (RHOO PI+ PI-)/(K KBAR PIO)

R2     D INTO (K KBAR PI)/(ETA PI PI)                    (P1)/(P3)
R2 K R      0.166     0.055         DEFOIX    68 HBC    1.2 PBAR P        1/73
R2          0.16      0.08          CAMPBELL  69 DBC    2.7 PI+ D         1/73
R2 K        0.20      0.08          DEFOIX    72 HBC    0.7 PBAR P,7 PI   1/73
R2          0.5       0.2           CORDEN    78 OMEG   12-15PI-P         4/78*
R2          0.42      0.15          GURTU     79 HBC    4.2 K- P         12/79*
R2         . . . . . . . . . .
R2  AVG     0.200     0.042    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R2  STUDENT 0.196     0.042    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R2 K    K KBAR SYSTEM CHARACTERIZED BY THE I=1 THRESHOLD
R2 K    ENHANCEMENT (SEE UNDER DELTA(980)).
R2   R  REVISED BY DEFOIX 72

R3     D INTO (DELTA PI)/(ETA PI PI)                     (P4)/(P3)
R3        SEEN                      DEFOIX    68 HBC    PBAR P            1/80*
R3         (0.8)     (0.2)          DEFOIX    72 HBC    0.7 PBAR P,7 PI . 1/73
R3          1.0       0.3           GRASSLER  77 HBC  0 16. PI-+ P       11/77
R3          0.6       0.3      0.2  CORDEN    78 OMEG   12-15PI-P         4/78*
R3          0.72      0.15          GURTU     79 HBC    4.2 K- P         12/79*
R3         . . . . . . . . . .
R3  AVG     0.74      0.12     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  STUDENT 0.73      0.13     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R4     D INTO (2PI+ 2PI- (INCL. RHO PI PI))/(ETA PI+ PI-)
R4                                                       (P5)/(2/3P3)
R4     50  (0.55) OR MORE           BOESEBECK 71 HBC    16. PI+- P,P 5PI 11/71
R4          0.46      0.15          GRASSLER  77 HBC    16. PI-+ P       11/77
R4         (0.4)  OR LESS  CL=.95   CORDEN    78 OMEG   12-15PI-P         4/78*
R4          0.32      0.20          GURTU     79 HBC    4.2 K- P         12/79*
R4         . . . . . . . . . .
R4  AVG     0.41      0.12     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4  STUDENT 0.41      0.13     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R5     D INTO (K* KBAR)/TOTAL                            (P6)
R5        NOT SEEN                  NACASH    77 HBC    .7+.76 PB P,KKBP 12/77

R6     D INTO (RHOO PI+ PI-)/(2PI+ 2PI-)                 (P2/P5)
R6          1.0       0.4           GRASSLER  77 HBC    16 GEV PI+- P    11/77

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REFERENCES FOR D

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D-ANDLAU 65 PL 17 347         +BARLOW,ADAMSON,+      (CDEF+CERN+IRAD+LIVP)
MILLER   65 PRL 14 1074       +CHUNG,DAHL,HESS,HARDY,KIRZ,+      (LRL+UCB)
BARLOW   67 NC  50 A  701     +MONTANET,D-ANDLAU+   (CERN+CDEF+IRAD+LIVP)
DAHL     67 PR 163 1377       +HARDY+HESS+KIRZ+MILLER              (LRL)I JP
C-ANDLAU 68 NP  B 5  693      +ASTIER,BARLOW+       (CDEF+CERN+IRAD+LIVP)I JP
DEFOIX   68 PL 28 B 353       +RIVET,SIAUD,CONFORTO+     (CDEF+IPNP+CERN)

CAMPBELL 69 PRL 22 1204       +LICHTMAN,+                          (PURD)
DCNALD   69 NP B 11 551       +EDWARDS,BURAN,BETTINI,+   (LIVP+OSLO+PADO)
LORSTAD  69 NP B 14 63        B.LORSTAD,D-ANDLAU,ASTIER,+     (CDEF+CERN)  JP
OTWINOWS 69 PL 29 B 529       S.OTWINOWSKI                       (WARSAW)

AMMAR    70 PR D2 430         +KROPAC,DAVIS,DERRICK+ (KANS+NWES+ANL+WISC)

BARDADIN 71 PR D4 2711        BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)
BOESEBEC 71 PL 34 B 659              (AACH+BERL+BONN+CERN+CRAC+HEID+WARS)
GOLDBERG 71 LNC 1 627         +MAKOWSKI,TOUCHARD,DONALD,+       (IPN+LIVP)  JP

BERENYI  72 NP B 37 621       +PRENTICE,STEENBERG,YOON,WALKER (TNTO+WISC)
CHAPMAN  72 NP B 42 1         +CHURCH,LYS,MURPHY,RING,VANDER VELDE (MICH)
DEFOIX   72 NP B 44 125       +NASCIMENTO,BIZZARRI,+          (CDEF+CERN)
DUBOC    72 NP B 46 429       +GOLDBERG,MAKOWSKI,DONALD,+     (LPNP+LIVP)
THUN     72 PRL 28 1733       +BLIEDEN,FINOCCHIARO,BOWEN,+    (STON+NEAS)

VUILLEMI 75 LNC 14 165        VUILLEMIN,+       (LAUS+NEUC+LPNP+LIVP+GLAS)  JP
WELLS    75 NP B 101 333      +RADOJICIC,ROSCOE,LYONS,+              (OXF)

HANDLER  76 NP B 110 173      +PLANO,BRUCKER,KOLLER+      (RUTG+STEV+SETO)
VUILLEMI 76 NC 33A 133        VUILLEMIN+        (LAUS+NEUC+LPNP+LIVP+GLAS)

GRASSLER 77 NP B 121 189      +(AACHEN+BERLIN+BONN+CERN+CRACOW+HEID+WARS)

CORDEN   78 NP B 144 253      +CORBETT,ALEXANDER,+  (BIRM+RHEL+TELA+LCWC)  JP
IRVING   78 NP B 139 327      A.C.IRVING,H.R.SEPANGI                (LIVP)
NACASCH  78 NP B 135 203      +DEFOIX,DOBRZYNSKI,+     (PARIS+MADRID+CERN)

GURTU    79 NP B 151 181      +GAVILLET,BLOKZIJL,+     (CERN+ZEEM+NIJM+OXF)
STANTON  79 PRL 42 346        +BROCKMAN,DANKOWYCH,+  (OSU+CARL+MCGI+TNTO)  JP

DIONISI  80  CERN-EP 80/1     +GAVILLET,ARMENTEROS+ (CERN+MACR+CDEF+STOH)
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ε(1300)

14 EPSILON(1300,JPG=0++) I=0

S-Wave ππ and $K\bar{K}$ Interactions

In this note we discuss information on the non-strange $I^G J^{PC} = 0^+ 0^{++}$ partial wave (S wave) coupled to the ππ and $K\bar{K}$ systems.

Near the ππ threshold the S wave shows no resonant behavior. For a discussion of the relevant scattering lengths and various resonance-like kinematic effects, see our 1978 edition.

Up to the ρ meson mass region, the phase shift δ_0^0 is (qualitatively) uniquely determined: it rises monotonically and reaches 60° to 70° near 700 MeV (SONDEREGGER 69, BATON 70, BAILLON 72, CARROLL 72, FRENKIEL 72, GAIDOS 72, PROTOPOPESCU 73, HYAMS 73, OCHS 73, ENGLER 74, ESTABROOKS 74,75, GRAYER 74).

In the early phase-shift analyses two solutions for δ_0^0 were found (the "up-down ambiguity") in the 700 to 900 MeV region. The "up" solution corresponds to an ε resonance under the ρ meson with mass and width similar to the ρ meson, the ε(800). The "down" solution is characterized by an approximately energy-independent phase shift of almost 90°, showing no resonant behavior. This ambiguity was considered resolved in favor of the "down" solution by the observation of a very rapid decrease in the modulus of the S-wave amplitude between 900 MeV and the $K\bar{K}$ threshold, followed by a sharp drop in the elasticity. δ_0^0 is ~90° at about 900 MeV and reaches ~180° around 990 MeV (FLATTE 72, GAIDOS 72, HYAMS 73, BINNIE 73, ENGLER 74). However, the region is complicated by the simultaneous presence of the S* resonance and the opening of the $K\bar{K}$ channel, permitting almost discontinuous jumps from one solution to another.

Without polarization information, the reaction $\pi N \rightarrow \pi\pi N$ cannot be analyzed unambiguously due to the fact that there are more helicity amplitudes than observables (see, e.g., DONOHUE 75). Thus one is obliged to make some supplementary assumptions.

An amplitude analysis (ESTABROOKS 74) of the largest $\pi^- p$ (unpolarized) $\rightarrow \pi^+\pi^- n$ experiment (HYAMS 73, GRAYER 74) still finds both the "up" and the "down" solutions. This analysis assumes both spin coherence (the unnatural-parity-exchange, s-channel helicity amplitudes are nucleon spin-flip, i.e., no A_1-like exchange) and phase coherence (the S-wave amplitude and the unnatural-parity-exchange, meson helicity-zero P-wave amplitude have the same phase). These assumptions may tend to bias the results (MORGAN 74, DONOHUE 75,79).

The advent of $\pi^- p$ (polarized) $\rightarrow \pi^+\pi^- n$ data (BECKER 79) has made both the spin coherence and phase coherence assumptions unnecessary. Analyzing their data in a model-independent way, BECKER2 79 also find both the "up" and the "down" solutions.

The reaction $\pi^+ p \rightarrow \pi^+\pi^-\Delta^{++}$ has been analyzed in the region 660 to 860 MeV (OWENS 76, DONOHUE 79) and in the region 600 to 920 MeV (GELFAND 78), using all the information carried by the Δ^{++} decay. The conclusion from both analyses is that the ε(800) of the "up" solution cannot be ruled out.

In a coupled-channel fit of various pole parametrizations to both $\pi\pi \rightarrow \pi\pi$ (ESTABROOKS 74) and $\pi\pi \rightarrow K\bar{K}$ data (CASON 76, PAWLICKI 77), ESTABROOKS 79 finds a pole located at 720 to 800 MeV with a width of 800 to 1000 MeV. Note that the "down" solution of ESTABROOKS 74 was used as input to this analysis. Further indirect information comes from elastic ππ scattering in the crossed channel (ELVEKJAER 72, NIELSEN 70,72) in agreement with the "down" solution, but not with the "up" solution.

The only way to rule out the "up" solution at present is to study the $\pi^0\pi^0$ system, where the "up" solution predicts a ρ-meson-like bump unmasked by the ρ meson. With the exception of one experiment (DAVID 77), all the $\pi^0\pi^0$ experiments agree that no

Data Card Listings
For notation, see key at front of Listings.

such bump is present and that the "down" solution describes the data well (DEINET 69, BENSINGER 71, APEL 72,79, BRAUN 73, SKUJA 73, RIESTER 75, BORREANI 79).

The region of elastic $\pi\pi$ scattering is known to extend to about 990 MeV, near the $K\bar{K}$ threshold (BATON 70, CARROLL 72, PROTOPOPESCU 73, HYAMS 73, OCHS 73). Beyond 1 GeV we therefore have to consider the two channels $\pi\pi$ and $K\bar{K}$. In addition, the solutions have inherent ambiguities related to the Barrelet zeros of the amplitudes. Thus HYAMS 75 find four solutions in the region 1.0 to 1.8 GeV, ESTABROOKS 74 find eight solutions, and CORDEN 79, extending the $\pi\pi$ analysis to 2.08 GeV, find another eight solutions.

In the past many of these solutions have been ruled out by imposing continuity in various ways, as well as analyticity and unitarity (FROGGATT 75,77, COMMON 76, MARTIN 78).

Now that data on π^-p (polarized) $\to \pi^+\pi^-n$ are available (BECKER 79), there is no need for such arguments. The model-independent partial-wave analysis of BECKER2 79 selects solution β' of MARTIN 78 and possibly solution β.

The β and β' amplitudes describe the experimental moments in each bin without any explicit smoothing; they are analytic in s and approximately analytic in $\cos\theta$. They take into account all waves up to $\ell=4$. The β solution has a highly elastic S wave, whereas the S wave of solution β' is somewhat inelastic (MARTIN 78). The unique solution of FROGGATT 77, which has explicit smoothness built in and which takes account only of $\ell \leq 3$ waves, is rather similar to β. However, it has problems with unitarity, apparently because of the neglected G wave (MARTIN 78).

The S wave is clearly resonant in the data of BECKER2 79. In the 1150 to 1400 MeV region both the S-P and S-D phase differences show the presence of a broad resonance, and the intensity of the S wave confirms this by exhibiting a peak at about 1300 MeV with a width of about 300 MeV; see Fig. 1(a).

The amplitude analysis of the $\pi^-p \to \pi^+\pi^-n$ experiment of CORDEN 79 has two preferred solutions which are close to β and β', giving some support for an $\epsilon(1300)$. Also the S wave in the $\pi^0\pi^0$ system

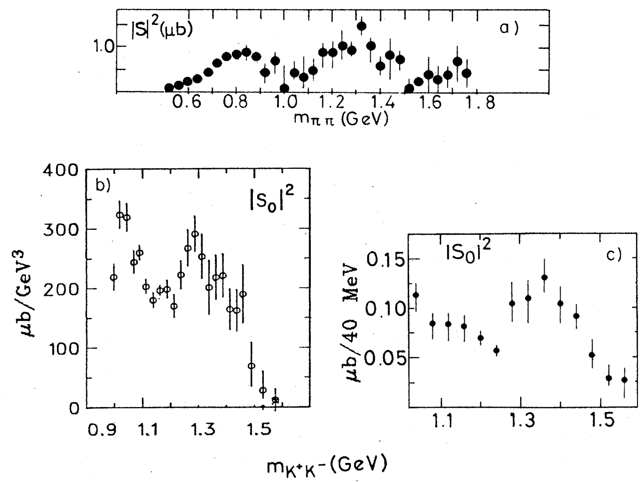

Fig. 1. (a) The absolute intensity (in μb) of the $\pi^+\pi^-$ S wave in 40 MeV bins (without dividing by the bin size), as given by the "down" solution of BECKER2 79. (b) Absolute intensity (in $\mu b/GeV^3$) of the K^+K^- S wave, as given by the favored solution of COHEN 78, for $|t| < 0.08$ GeV^2. (c) The absolute intensity (in μb/40 MeV bin) of the K^+K^- S wave, as given by the favored solution of GORLICH 79.

tends to confirm the $\epsilon(1300)$ by staying near its unitarity limit around 1200 MeV (APEL 79).

Independent evidence for the $\epsilon(1300)$ comes from studies of the $K\bar{K}$ systems. In the reaction $\pi^-p \to K^0_SK^0_Sn$, the S wave exhibits a large intensity in the 1300 MeV region (WETZEL 76, LOVERRE 79), with some evidence for a bump. Moreover, the $\langle Y^2_0 \rangle$ moment shows a large negative excursion indicating S-D interference (CASON 76, WETZEL 76, LOVERRE 79, POLYCHRONAKOS 79). The main problem is the isospin of the bump: if OPE were the only mechanism, I=0 would be assured. However, an I=1 non-OPE contribution in the same region cannot be excluded. Moreover, the I=1 K^-K^0 system does show some peaking (MARTIN 79), so one will possibly have to disentangle two resonances in the $K^0_SK^0_S$ bump.

In agreement with this, the K^+K^- system produced in π^-p, π^+n, and π^-p (polarized) scattering clearly shows the S wave peaking at 1300 MeV; again, both I=0 and I=1 may be present. While PAWLICKI 77, COHEN 78, and GORLICH 79 favor I=0, MARTIN 79 concludes that the isospin cannot be assigned unambiguously. The experiments disagree on the strength of the $\epsilon(1300)$ coupling to $K\bar{K}$.

Mesons

ϵ(1300)

The ANL group (PAWLICKI 77, COHEN 78) find a relatively narrow ε with a width ~200 MeV [see Fig. 1(b)], whereas the GORLICH 79 peak is smaller and broader [see Fig. 1(c)]. Part of the disagreement may be due to model-dependent assumptions in the ANL analysis. Note, however, that the S-wave amplitude and phase of the ANL experiment are impossible to fit with an S^* and a narrow ε(1300) (MARTIN 79). On the other hand, the ANL S-wave amplitude and phase are quite well described by an S^* and a broad ε(1300), just as are the amplitude and phase of GORLICH 79.

Thus in summary of the 1000 to 1400 MeV region: the ε(1300) exists, it is about 300 MeV wide, and it couples to $K\bar{K}$ with a branching ratio of the order of 7% (GORLICH 79, LOVERRE 79) or $\lesssim$ 10% (ESTABROOKS 79, GREENHUT 79). The elasticity of the β' solution (MARTIN 78) also seems to be of this order of magnitude.

Above the ε(1300) resonance the phase shift has completed a full circle in the Argand plane, as witnessed by the almost vanishing amplitude near 1550 MeV (BECKER2 79, GORLICH 79).

14 EPSILON MASS (MEV)

M	(1256.0)		FROGGATT	77	RVUE	PI+PI- CHANNEL	12/77
M	(1270.)	APPROX.	MARTIN	78	RVUE	PI+PI- CHANNEL	12/77
M	(1300.)	APPROX.	PAWLICKI	77	SPEC	6. PI N,K+ K- N	12/77
M	(1300.)	APPROX.	POLYCHRON	79	STRC	7. PI-P,KS KS N	12/79*

14 EPSILON WIDTH (MEV)

W	E	(400.)	APPROX.	FROGGATT	77	RVUE	PI+PI- CHANNEL	12/77
W		(150.)	APPROX.	PAWLICKI	77	SPEC	6. PI N,K+ K- N	12/77
W		(150.)	APPROX.	POLYCHRON	79	STRC	7. PI-P,KS KS N	12/79*
W	E	WIDTH DEFINED AS DISTANCE BETWEEN 45 AND 135 DEGREES PHASE SHIFT.						12/77

REFERENCES FOR EPSILON

SAMIOS 62 PRL 9 139 +BACHMAN,LEA+ (BNL+CUNY+COLU+KNTY)

BLOKHINT 63 JETP 17 80 BLOKHINTSEVA,GREIBINNIK,ZHUKOV + (DUBNA)
BOOTH 63 PR 132 2314 + ABASHIAN (LRL)
KIRZ 63 PR 130 2481 +SCHWARTZ + TRIPP (LRL)

BARISH 64 PR 135 B 416 BARISH,KURZ,PEREZ-MENDEZ,SOLOMON (LRL)
CRAWFORD 64 PRL 13 421 +GROSSMAN,LLOYD,PRICE,FOWLER (LRL)
DEL FABR 64 PRL 12 674 DEL FABRO,DE PRETIS,JONES+ (FRASCATI)
KALMUS 64 PRL 13 99 +KERNAN,PU,POWELL,DOWD (LRL+WISCONSIN)

BATON 65 NC 36 1149 J.P.BATON, J.REGNIER (SACLAY)
BIRGE 65 PR 139 B 1600 +ELY+GIDAL+KALMUS+CAMERINI+ (LRL+WISC)
BROWN 65 CORAL GABLES 219 BROWN+FAIER (NORTHWESTERN)
DURAND 65 PRL 14 329 L. DURAND AND Y.T. CHIU (YALE)

JACOBS 66 PRL 16 669 +SELOVE (LRL)
KOPELMAN 66 PL 22 118 +ALLEN,GODDEN,MARSHALL + (COLORADO+IOWA)
LOVELACE 66 PL 22 332 LOVELACE,HEINZ,DONNACHIE (CERN)

ANDERSON 67 PRL 18 89 +FUKUI+KESSLER+ (CHIC+ANL+CNRC+MCGILL+LOQM)
CLEGG 67 PR 163 1664 A.B.CLEGG (LANCASTER)
CORBETT 67 PR 156 1451 +DAMERELL+MIDDLEMAS+NEWTON (OXF+RHEL)
GUTAY 67 PRL 18 142 +JOHNSON+LOEFFLER+MCILWAIN+ (PURDUE+LRL)
JOHNSON 67 PR 163 1497 +GUTAY,EISNER,KLEIN,PETERS,SAHNI,YEN+(PURD)
MALAMUD 67 PRL 19 1056 E.MALAMUD + P.E.SCHLEIN (UCLA)
WALKER 67 RMP 39 695 W.D.WALKER (WISCONSIN)
WALKER 67 PRL 18 630 +CARROLL,GARFINKEL,OH (WISCONSIN)

BANDER 68 PR 168 1679 +SHAW,FULCO (UC IRVINE+S.BARBARA)
BISWAS 68 PL 27 B 513 +CASON,JOHNSON,KENNEY,POIRIER+ (NDAM)
BRAUN 68 PRL 21 1275 BRAUN,CLINE,SCHERER (WISCONSIN)
DUTTA-RO 68 PR 169 1357 B. DUTTA-ROY, I.R. LAPIDUS (STEV)
EISENHAN 68 PRL 20 758 EISENHANDLER,MISTRY,MOSTEK + (CORNELL)
FOSTER 68 NP B 6 107 +GAVILLET+LABROSSE+MONTANET+ (CERN+CDEF)
HYAMS 68 NP B7 1 +KOCH,POTTER,..VON LINDERN,LOREN(CERN+MPIM)
JONES 68 PR 166 1405 +CALDWELL+ZACHAROV+HARTING+BLEULER+ (CERN)
JOHNSON 68 PR 176 1651 +POIRIER,BISWAS,GUTAY+ (NDAM+PURD+SLAC)
LOVELACE 68 PL 28 B 264 C.LOVELACE (CERN)
MARATECK 68 PRL 21 1613 +HAGOPIAN,+ (PENN+LRL+COLO+PURD+TNTO+WISC)

BIZZARRI 69 NP B14 169(SEE P.190)+FOSTER,GAVILLET,GHESQUIERE+ (CERN+CDEF)
DAVISON 69 PR 180 1333 +BACASTOW,BARKAS,+ (UCR+UCB)
DEINET 69 PL 30 B 359 +MENZIONE,MULLER,STAUDENMAIER,+ (KARL+CERN)
ELY 69 PR 180 1319 +GIDAL,HAGOPIAN,+ (UCB+LOUC+WISC)
FELDMAN 69 PRL 22 316 +FRATI,GLEESON,HALPERN,NUSSBAUM,+ (PENN)
GUTAY 69 NP B 12 31 +CARMONY,CSONKA,LOEFFLER,MEIERE (PURDUE)
HALL 69 NP B 12 573 +MURRAY,RIDDIFORD (BIRMINGHAM)
HOPKINSO 69 NC 59 A 181 J.HOPKINSON,R.G.ROBERTS (CERN)
MALAMUD 69 ARGONNE CONF.P.93 E.MALAMUD, P.SCHLEIN (UCLA)
MORGAN 69 NP B 10 261 D.MORGAN,G.SHAW (RHEL)
ROBERTS 69 PL 29 B 368 R.G. ROBERTS, F. WAGNER (CERN)
SCHAREN1 69 ARGONNE CONF.306 SCHARENGUIVEL (PURDUE)
SCHAREN2 69 PR 186 1387 SCHARENGUIVEL(PURD+LRL+CERN+COLO+PENN+TNTO)
SMITH 69 PRL 23 335 G.A.SMITH, R.J.MANNING (MSU+LRL)
SONDEREG 69 SEE BASDEVANT 72 SONDEREGGER, BONAMY (SACL)
STRUGALS 69 PL 29 B 518 +CHUVILO,FENYVES,+ (WARS+JINR+BUDA)
ALSO 70 NP B 24 358 STRUGALSKI,CHUVILO,FENYVES,GEMESY,+ (DUBNA)
WAGNER 69 NC 64 A 189 F.WAGNER (CERN)

BARTSCH 70 NP B 22 1 +KEPPEL,GENSCH,MORRISON,+ (AACH+BERL+CERN)
BATON 70 PL 33 B 528 +LAURENS,REIGNIER (SACLAY)
BRODY 70 PRL 24 948 +GROVES,VANBERG,MAGLIC+(PENN+RUTG+UPNJ+ANL)
DIAZ 70 NP B 16 239 +GAVILLET,LABROSSE,MONTANET+ (CERN+CDEF)
HYAMS 70 PHILAD.CONF.P.41 +SCHLEIN,BEUSCH,+ (CERN+MPIM+ETH+LOIC+HAWA)
MAUNG 70 PL 33 B 521 +MASEK,MILLER,RUDERMAN,VERNON,+ (UCSD+LRL)
MORGAN1 70 SPRINGER TRACTS MOD.PHYS.,VOL.55,P.1. MORGAN,PISUT(RHEL+CERN)
MORGAN 2 70 PR D 2 520 D.MORGAN,G.SHAW (RHEL)
NIELSEN 70 NP B 22 525 +LYNG-PETERSEN,PIETARINEN (NORDITA)
OH 70 PR D 1 2494 +GARFINKEL,MORSE,WALKER,PRENTICE(WISC+TNTO)
SCHARENG 70 NP B 22 16 SCHARENGUIVEL,GUTAY,MILLER,+ (PURD+PENN)
SHIBATA 70 PRL 25 1227 +FRISCH,WAHLIG (MIT)

ALSTON-G 71 PL 36 B 152 ALSTON-GARNJOST,BARBARO-GALTIERI,+ (LBL)
BANAIGS 71 NP B 28 509 +BERGER,DUFLO,GOLDZAHL,COTTEREA+(SACL+CAEN)
BEAUPRE 71 NP B 28 77 +DEUTSCHMANN,GRAESSLER,+ (AACH+BERL+CERN)
BENSINGE 71 PL 36 B 134 BENSINGER,ERWIN,THOMPSON,W.D.WALKER (WISC)
DUBAL 71 NP B 32 535 L.DUBAL,D.J.BROWN (CNRC+CARL)
GUILLOU 71 NC 5 A 659 LE GUILLOU,MOREL,NAVELET (CERN)
GUTAY 71 NP B 27 486 +SCHARENGUIVEL,FUCHS,GAIDOS,MILLER,+ (PURD)
HAMILTON 71 SPRINGER TRACTS MOD.PHYS.,VOL. 57,P.41 J.HAMILTON (NORDITA)
KIM 71 PR D 4 265 +BANDER (UCI)
LYNG PET 71 PHYS.REPRTS 2 155 J.LYNG PETERSEN (REVIEW) (CERN)

APEL 72 PL 41 B 542 +AUSLANDER,MULLER,BERTOLUCCI,+ (KARL+PISA)
BAILLON 72 PL 38 B 555 +CARNEGIE,KLUGE,LEITH,LYNCH,RATCLIFF+(SLAC)
BASDEVAN 72 PL 41 B 178 BASDEVANT,FROGGATT,PETERSEN (CERN)
BRODY 1 72 PRL 28 1215 +GROVES,MAGLICH,NOREM,+ (PENN+RUTG+UPNJ)
BRODY 2 72 PRL 28 1217 H.BRODY (PENNSYLVANIA)
CARROLL 72 PRL 28 318 +DIAMOND,FIREBAUGH,MATTHEWS,+ (WISC+TNTO)
ELVEKJAE 72 NP B 43 445 F.ELVEKJAER (AARHUS)
FLATTE 72 PL 38 B 232 +ALSTON-GARNJOST,BARBARO-GALTIERI, (LBL)
FRENKIEL 72 NP B 47 61 +GHESQUIERE,LILLESTOL,CHUNG,+ (CDEF+CERN)
GAIDOS 72 NP B 46 449 +MCILWAIN,THOMPSON,WILLMANN (PURDUE)
PRASAD 72 PR D 6 3216 +BREHM (UNIV.OF MASSACHUSETTS)
NIELSEN 72 NP B 49 586 H.NIELSEN,G.OADES (NORD+AARHUS)
WHITEHEA 72 NP B 48 365 WHITEHEAD,AULD,+ (AERE+RHEL+SHMP+LCUC)
WILLIAMS 72 PR D 6 3178 P.K.WILLIAMS (FSU)
ZYLBERSZ 72 PL 38 B 457 ZYLBERSZTEJN,BASILE,BOURQUIN,+ (GEVA+SACL)

ANJOS 73 NP B 67 37 +D.LEVY,A.SANTORO (SACLAY)
BANAIGS1 73 PL 43 B 535 +COTTEREAU,FABBRI,+ (SACL+CAEN+FRAS)
BANAIGS2 73 NP B 67 1 +BERGER,GOLDZAHL,COTTEREAU,+ (SACL+CAEN)
BASDEVAN 73 AIX CONF.P.220 J.L.BASDEVANT RAPPORTEUR TALK (PARIS VI)
BEIER 73 PRL 30 399 +BUCHHOLZ,MANN,PARKER,ROBERTS (PENN)
BINNIE 73 PRL 31 1534 +CARR,DEBENHAM,DUANE,GARBUTT,+ (LOIC+SHMP)
BRAUN 73 PR D 8 3794 +D.CLINE (WISC)
HYAMS 73 NP B 64 134 +JONES,WEILHAMMER,BLUM,DIETL,+ (CERN+MPIM)
FOR OTHER RESULTS ON SAME EXPERIMENT SEE GRAYER 74
OCHS 73 THESIS THESIS (MPIM)
PILKUHN 73 NP B 65 460 +SCHMIDT,MARTIN,+ (KARL+CERN+LOUC+NIJM)
PROTOPOP 73 PR D 7 1280 PROTOPOPESCU,GARNJOST,GALTIERI,FLATTE+(LBL)
RISSER 73 PL 43 B 68 T.RISSER,M.D.SHUSTER (SACL)
SKUJA 73 PRL 31 653 +WAHLIG,RISSER,PRIPSTEIN,NELSON,+ (LBL)

BASDEVAN 74 NP B 72 413 BASDEVANT,FROGGATT,PETERSEN (LPTP+NORD)
BONNIER 74 NP B 83 440 B.BONNIER,N.JOHANNESSON (CERN)
CARROLL 74 PR D 10 1430 +MATTHEWS,WALKER+ (SLAC+DUKE+WISC+TNTO)
ENGLER 74 PR D 10 2070 +KRAEMER,TOAFF,WEISSER,DIAZ+ (CARN+CASE)
ESTABROO 74 NP B 79 301 P.ESTABROOKS,A.D.MARTIN (DURH)
GRAYER 74 NP B 76 375 +HYAMS,JONES,BLUM,DIETL (CERN+MPIM)
JONES 74 NP B 83 93 +ALLISON,SAXON (OXF)
MORGAN 74 PL 51 B 71 D.MORGAN (RHEL)
ORITO 74 PL 48 B 380 +FERRER,PAOLUZI,SANTONICO (FRAS+ROMA)
PASCUAL 74 NP B 83 362 P.PASCUAL,F.J.YNDURAIN (BARC+MADU)

BAR-NIR 75 NP B 87 109 +RISSER,SHUSTER (CERN+UCSB+TELA)
BARRY 75 NP B 85 239 G.W.BARRY (PURD)
BASDEVAN 75 NP B 98 285 BASDEVANT,CHAPELLE,LOPEZ,SIGELLE (LPTP)
DONOHUE 75 NC 25 A 409 J.T.DONOHUE,Y.LEROYER (BORD)
ESTABROO 75 NP B 95 322 P.ESTABROOKS,A.D.MARTIN (DURH)
FROGGATT 75 NP B 91 454 C.D.FROGGATT,J.L.PETERSEN (GLAS+NORD)
FUJII 75 NP B 85 179 Y.FUJII,M.FUKUGITA (TOKY)
HYAMS 75 NP B 100 205 +JONES,WEILHAMMER,BLUM,DIETL+ (CERN+MPIM)
MORGAN 75 ARGONNE CONF. 45 D.MORGAN (RHEL)
RIESTER 75 NP B 96 407 +ARNOLD,ENGEL,PATY (STRB)
SHIMADA 75 NP B 100 225 T.SHIMADA (TOKY)
SRINIVAS 75 PR D 12 681 SRINIVASAN,HELLAND,LENNOX,KLEM+ (NDAM+ANL)

BANAIGS 76 NP B 105 52 +BERGER,GOLDZAHL,COTTEREAU+(SACL+CAEN+FRAS)I,JP
CASON 76 PRL 36 1485 +POLYCHRONAKOS,BISHOP,BISWAS,+ (NDAM+ANL)I J
CERRADA 76 PL 62 B 353 +GONZALEZ-ARROYO,RUBIO,YNDURAIN (CERN+MADR)
COMMON 76 NP B 103 109 A.K.COMMON (KENT) JP
FLATTE 76 PL 63 B 228 S.M.FLATTE (CERN)
GRIVAZ 76 PL 61 B 400 +DAVIS,HALSTEINSLID,IRWIN,+(LALO+BERG+EPOL)
OWENS 76 NP B 112 514 +EISNER,CHUNG,PROTOPOPESCU (CASE+BNL)
PAWLICKI 76 PRL 37 1666 +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND (ANL)I,JP
WETZEL 76 NP B 115 208 +FREUDENREICH,BEUSCH,+ (ETH+CERN+LOIC)

AGUILAR 77 NP B +CERRADA,+ (MADRID+BOMBAY+CERN+PARIS)
FROGGATT 77 NP B 129 89 +PETERSEN (GLASGOW+COPENHAGEN)
DAVID 77 PR D 16 2027 +VILLET,AYED,BAREYRE,BORGEAUD,+ (SACL)
MARTIN 77 NP B 121 514 +OZMUTLU,SQUIRES (DURHAM)
PAWLICKI 77 PR D 15 3196 +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND (ANL)I J
ROSSELET 77 PR D 15 574 +EXTERMANN,FISHER,BERGER,BLOCH,+(GEVA+SACL)

GELFAND 78 NP B 138 365 +DAGAN,LISSAUER,OREN,ABRAMS+ (TELA+UCB)
HOLMGREN 78 PL 77 B 304 +PENNINGTON (STOH+CERN)
MARTIN 78 ANP 114 1 A.D.MARTIN,M.R.PENNINGTON (CERN)

ACHASOV 79 PL B 88 367 +DEVYANIN,SHESTAKOV (NOVO)
APEL 79 NP B 160 42 +AUSLANDER,MULLER,REHAK+ (KARL+PISA)
BECKER 1 79 NP B 150 301 +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
BECKER 2 79 NP B 151 46 +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
BORREANI 79 NP B 147 28 +FISHER,GUY,ELY,LEUTZ,+(TORI+RHEL+LBL+CERN)
COHEN 78 ANL-HEP-PR-78-22 +AYRES,DIEBOLD,KRAMER,PAWLICKI+ (ANL)I,JP
CORDEN 79 NP B 157 250 +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC) JP
DONOHUE 79 NP B 158 123 +LEROYER (BORD+ANL+OXF)

Data Card Listings

For notation, see key at front of Listings.

ESTABROO 79 PR D 19 2678 P.ESTABROOKS (CARL)
GORLICH 79 CERN/EP 79-139 +NICZYPORUK,ROZANSKA+ (CRAC+MPIM+CERN+ZEEM)
GREENHUT 79 PR D 20 2326 +INTEMANN (SETO)
LOVERRE 79 CERN/EP 79-162 +ARMENTEROS,DIONISI+ (CERN+CDEF+MADR+STOH)I,JP
MARTIN 79 NP B 158 520 +OZMUTLU (DURH)I,JP
POLYCHRO 79 PR D 19 1317 POLYCHRONAKOS,CASON,BISHOP+ (NDAM+ANL)I,JP

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$A_2(1310)$

12 A2(1310,JPG=2+-) I=1

WE LIST THE A2 AS AN ORDINARY BREIT-WIGNER RESONANCE.
FOR DISCUSSION OF THE REPORTED SPLITTING, SEE OUR
APRIL 72 AND APRIL 73 EDITION.

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12 A2 MASS (MEV), 3PI MODE

M			(1320.0)		ADERHOLZ	64	HBC		4.0 PI+P	
M			(1335.0)	(10.0)	GOLDHABER	64	HBC	+-	3.7 PI+- P	12/75
M		1425	1290.0	(5.0)	LEFEBVRES	65	MMSP	-	5.6,6.0 PI-P	1/73
M			(1290.0)	(10.0)	BARNES	66	HBC	-	6.0 PI-P	2/73
M			(1310.0)	(10.0)	BENSON	66	DBC	0	3.65 PI+D	12/75
M		1060	1286.	(8.)	LEVRAT	66	MMS	-	6-7 PI- P	1/73
M	O	4000	(1307.)	(16.)	CHIKOVANI	67	MMS	-	7 PI- P	12/75
M		260	1311.0	6.0	ARMENISE	68	DBC	0	5.1 PI+D	9/67
M		120	1320.	10.	BOESEBECK	68	HBC	0	8 PI+ P	6/68
M	O		(1310.)	(20.)	CHUNG	68	HBC	-	2.7-4.5 PI- P	5/68
M			(1301.0)	(8.0)	VON KROGH	68	HBC	-	6.7 PI- P	9/68
M	A		(1300.0)	(4.0)	JUNKMANN	68	HBC	-	16. PI- P, 5PI	1/73
M	A		(1299.)	(14.)	LAMSA	68	HBC	-	8 PI- P	1/71
M	O		(1295.0)	(20.0)	ANDERSON	69	MMS	-	16 PI- P,BACKW9	8/69
M	A	241	(1299.0)	(12.0)	ARMENISE	69	DBC	+	5.1 PI+D,3PI++-	5/70
M			1310.0	14.0	EISENBERG	69	HBC	+	4.3,5.3 GAMMA P	12/69
M			1305.	(3.)	ASCOLI	70	HBC	-	5 - 7.5 PI- P	1/71
M		941	1306.0	4.0	ALSTON	70	HBC	+	7.0 PI+P,3PI P	1/71
M		280	1313.0	7.0	BOCKMANN	70	HBC	0	5. PI+P	5/70
M	A	581	(1288.0)	(10.0)	CASO	70	HBC	-	11.2PI-P,PI RHO	1/73
M	O		(1335.0)	(15.0)	DIAZ	70	HBC	+-	0. PBAR P, 4 PI	12/75
M	O		(1330.0)	(15.0)	GARFINKEL	70	DBC	-	4.5 K-D,LAMBDA	12/75
M		360	1304.0	4.5	BARNHAM	71	HBC	+	3.7 PI+ P,(3PI)+	11/71
M		10000	1307.	5.	BINNIE1	71	MMS	-	PI-P NEAR A2 THR	11/71
M		5000	1309.	5.	BINNIE1	71	MMS	-	PI-P NEAR A2 THR	11/71
M		28000	1299.0	6.0	BOWEN	71	MMS	-	5. PI- P	11/71
M		24000	1300.	6.0	BOWEN	71	MMS	+	5. PI+ P	11/71
M		17000	1309.0	4.0	BOWEN	71	MMS	-	7. PI- P	11/71
M		160	1307.	7.	BLOODWORT	72	HBC	+	5.45 PI+ P,P 3PI	1/73
M	P		1315.	5.	ANTIPOV1	73	CNTR	-	25.,40. PI- P	1/74
M		1580	1306.	9.	CHALOUPKA	73	HBC	-	3.9 PI- P,P A2	2/73
M	P	1600	1318.	7.	EMMS	75	DBC	0	4. PI+N,P A20	11/75
M	P	1200	1298.	8.	WAGNER	75	HBC	0	7. PI+P,DEL++A2	11/75
M	P	3000	(1318.0)	(2.0)	GHIDINI	77	OMEG	-	12 PI-P,P 3PI	12/77
M		1097	1320.0	10.0	BALTAY 1	78	HBC	+0	15 PI+P,P 4PI	4/78*
M	P	490	(1343.0)	(11.0)	BALTAY 1	78	HBC	0	15 PI+P,DEL 3PI	4/78*
M			1285.0	9.0	CORDEN 2	78	OMEG	-	12-15 PI-P,3PI N	4/78*
M			1306.0	8.0	FERRER	78	OMEG	-	9 PI-P,P 3PI	4/78*
M	P	25000	1317.0	2.0	DAUM	80	SPEC	-	63,94 PI- P= 3PI	12/79*
M			. . . . .	. . . . . .						
M	AVG		1310.5	1.6	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)					
M	STUDENT		1309.5	1.6	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					
				(SEE IDEOGRAM BELOW)						

M O ONLY EXPERIMENTS GIVING ERROR LESS THAN 15 MEV KEPT FOR AVERAGING
M A ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5) AND/OR A1
M P FROM A FIT TO JP=2+ RHO PI PARTIAL WAVE

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12 A2 MASS (MEV), K KBAR MODE

MK		80	(1317.0)	(3.0)		BARLOW	67	HBC	+-	1.2 PBAR P, KK .	2/72
MK		60	1333.0	13.0		BARLOW	67	HBC	+-	1.2 PBAR P, KK	9/67
MK	N		(1344.0)	(7.)	(6.)	BEUSCH	67	OSPK	0	5-12 PI-P,K1K1	11/71
MK		130	1280.0	12.0		CONFORTO	67	HBC	+-	0. PBAR P IN KK.	9/67
MK			1317.2	4.0		DAHL	67	HBC	-	2.7-4.5 PI- P	8/67
MK	N		(1315.7)	(10.8)		DAHL	67	HBC	0	2.7-4.5 PI- P	11/71
MK	N		(1311.0)	(5.0)		CRENNELL	68	HBC	0	6.0 PI-P,K1K1	11/71
MK		132	1301.0	7.0		ALSTON	70	HBC	+	7.0 PI+P,K+KS P	1/71
MK		190	1313.0	7.0		CRENNEL	71	HBC	-	4.5 PI- P,KSK-P	11/71
MK	S	1500	1319.0	3.0		GRAYER	71	ASPK	-	17.2 PI-P,K-KS P	2/72
MK		730	1313.0	4.0		FOLEY	72	CNTR	-	20.3 PI- P,K- KS	12/72
MK		2724	1320.0	2.0		MARGULIES	76	SPEC	-	23.PI-P,K-KS	12/77
MK		11000	1312.0	4.0		CHABAUD	78	SPEC	-	9.8 PI-P,K- KS P	4/78*
MK		4730	1316.0	2.0		CHABAUD	78	SPEC	-	18.8PI-P,K- KS P	4/78*
MK		350	1324.0	5.0		HYAMS	78	ASPK	+	12.7 PI+P,K+KS P	4/78*
MK	P S		1318.	1.		MARTIN 1	78	SPEC	-	10 PI P,KS K- P	4/78*
MK		4000	(1320.0)	(2.0)		CHABAUD	79	SPEC	+	17PI-NUCLEI,KSK-	12/79*
MK			. . . . .	. . . . .							
MK	AVG		1317.47	0.89	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)						
MK	STUDENT		1317.57	0.83	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT						
				(SEE IDEOGRAM BELOW)							

MK N THE NEUTRAL MODE CAN INTERFERE WITH THE F MESON
MK S SYSTEMATIC ERROR IN MASS SCALE SUBTRACTED
MK P FROM A FIT TO JP=2+ PARTIAL WAVE

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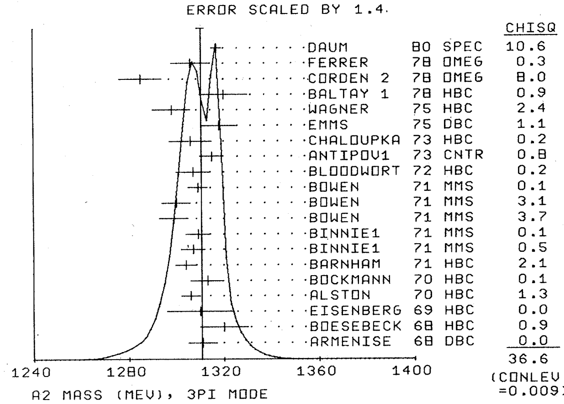
12 A2 MASS (MEV), ETA PI MODE

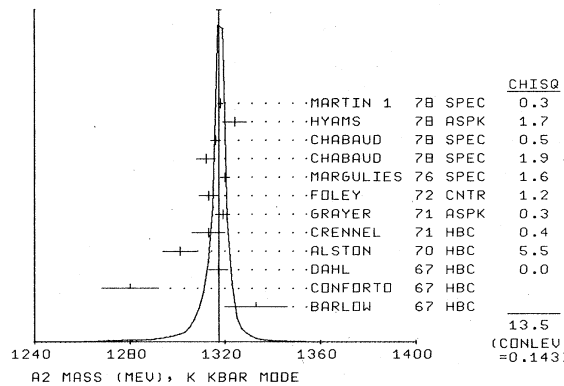
M		189	1312.0	7.0	ALSTON	70	HBC	+	7.0 PI+P,PI ETA	1/71
M			1300.0	20.0	CASO	70	HBC	-	11.2PI-P,PI ETA	5/70
M		32	1300.0	8.	DZIERBA	70	HBC	-	8. PI- P,PI ETA	1/73
M		30	1288.	7.	JOHNSTON	70	HBC	-	7.PI-P,PI-ETA P	1/71
M			1320.	20.	ESPIGAT	72	HBC	+-	0.PBAR P,ETA 2PI	11/71
M	E	1000	1323.	8.	KEY	73	OSPK	-	6.PI-P,P PI-ETA	1/74
M	EM	6200	(1324.)	(8.)	CONFORTO	73	OSPK	-	6.PI-P,P MMS-	1/74
M			. . . . .	. . . . .						
M	AVG		1305.3	5.8	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)					
M	STUDENT		1306.0	5.0	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					
				(SEE IDEOGRAM BELOW)						

M E ERROR INCLUDES 5 MEV SYSTEMATIC MASS-SCALE ERROR
M M MISSING MASS WITH ENRICHED MMS=ETA PI-, ETA = 2 GAMMA

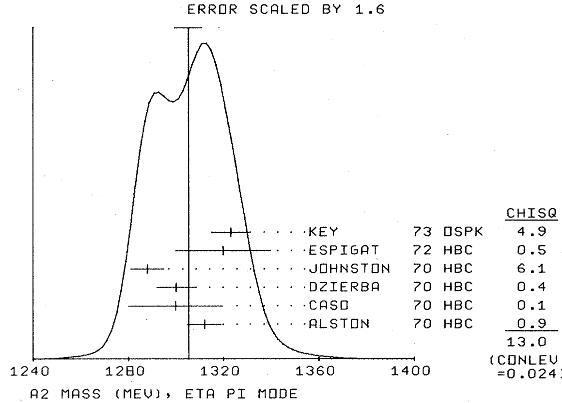
WEIGHTED AVERAGE = 1310.5 ± 1.6
ERROR SCALED BY 1.4



WEIGHTED AVERAGE = 1317.47 ± 0.89
ERROR SCALED BY 1.2



WEIGHTED AVERAGE = 1305.3 ± 5.8
ERROR SCALED BY 1.6



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Mesons

$A_2(1310)$

Data Card Listings

For notation, see key at front of Listings.

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                    12  A2 WIDTH (MEV), 3PI MODE

W            (100.0)                      ADERHOLZ  64 HBC       4.0 PI+P
W             (90.0)   (10.0)             GOLDHABER 64 HBC  +-   3.7 PI+- P        12/75
W     1425     99.0    (15.0)             LEFEBVRES 65 MMSP  -   6.0 PI-P           1/73
W             (70.0)   (10.0)             BARNES    66 HBC   -   6.0 PI-P           2/73
W            (100.)    (15.)              BENSON    66 DBC    0 3.65 PI+D          12/75
W     1060     98.      (5.)              LEVRAT    66 MMS   -   6,7 PI- P          1/73
W   0 4000    (90.)    (15.)              CHIKOVANI 67 MMS   -   7 PI- P           12/75
W      260     96.0     16.0              ARMENISE  68 DBC    0 5.1 PI+D            9/67
W   0  120    (56.)    (21.)              BOESEBECK 68 HBC    0 8 PI+ P             1/73
W   0         (80.)    (20.)              CHUNG     68 HBC   -  2.7-4.5 PI- P       5/68
W             (40.0)   (25.0)             VON KROGH 68 HBC   -  6.7 PI- P           9/68
W   A         (52.0)   (16.0)             JUNKMANN  68 HBC   -  16. PI- P, 5PI      1/73
W   0         (90.0)   (10.0)   (50.0)    ANDERSON  69 MMS   -  16 PI- P,BACKW9    12/75
W   AE 241   (164.0)   (20.0)             ARMENISE  69 DBC  +   5.1 PI+D,3PI++-     5/70
W   0         (80.0)   (30.0)             EISENBERG 69 HBC  +  4.3,5.3 GAMMA P    12/69
W      941     79.0     12.0              ALSTON    70 HBC  +  7.0 PI+P,3PI P       1/71
W   0  280    (70.0)   (29.0)             BOCKMANN  70 HBC    05. PI+P              5/70
W   A  581   (135.0)   (26.0)             CASO      70 HBC   - 11.2PI-P,PI RHO      1/73
W   0         (90.0)   (20.0)             DIAZ      70 HBC  +- 0. PBAR P, 4 PI      5/70
W   D         (35.0)   (35.0)             GARFINKEL 70 DBC   -  4.5 K-D,LAMBDA      1/71
W      360    111.4     18.0              BARNHAM   71 HBC  +  3.7 PI+ P,(3PI)+  11/71
W    10000   (100.)                       BINNIE1   71 MMS   - PI-P NEAR A2 THR   11/71
W     5000     72.      16.               BINNIE1   71 MMS   - PI-P NEAR A2 THR   11/71
W    28000    105.0      5.0              BOWEN     71 MMS   - 5. PI- P           11/71
W    24000     99.0      5.0              BOWEN     71 MMS  +  5. PI+ P           11/71
W    17000    103.0      5.0              BOWEN     71 MMS   - 7. PI- P           11/71
W   0  160    (72.)    (25.)              BLOODWORT 72 HBC  +  5.45 PI+ P,P 3PI  12/72
W  P          115.      15.               ANTIPOV1  73 CNTR -  25.,40. PI- P      1/74
W     1580     99.      15.               CHALOUPKA 73 HBC  -  3.9 PI- P,P A2     2/73
W  P  1600    112.      18.               EMMS      75 DBC    04.  PI+N,P A20    11/75
W  P S1200    122.      14.               WAGNER    75 HBC    07.  PI+P,DEL++A2  11/75
W  P  3000   (130.0)    (7.0)             GHIDINI   77 OMEG   -12 PI-P,P 3PI     12/77
W     1097    110.0     15.0              BALTAY 1  78 HBC  +0 15 PI+P,P 4PI      4/78*
W   P  490   (115.0)   (14.0)             BALTAY 1  78 HBC   0 15 PI+P,DEL 3PI    4/78*
W             150.0     20.0              CORDEN 2  78 OMEG  - 12-15 PI-P,3PI N   4/78*
W  P 25000     96.0      9.0              DAUM      80 SPEC  - 63,94 PI- P= 3PI  12/79*
W            . . . . . . . . . .
W   AVG       102.2      2.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
W   STUDENT   102.2      2.7     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )

W   0   ONLY EXPERIMENTS GIVING MASS ERROR LT. 15 MEV KEPT FOR AVERAGING
W   E   BACKGROUND SUBTRACTION MODEL-DEPENDENT.
W   D   MAY BE DIFFERENT OBJECT, ALTHOUGH JPC=2++. COMPARE CRENNELL 69.
W  A    ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5) AND/OR A1
W    S  WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE
W  P    FROM A FIT TO JP=2+ RHO PI PARTIAL WAVE

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                    12  A2 WIDTH (MEV), K KBAR MODE

WK        60   56.0     28.0              BARLOW     67 HBC  +-  1.2 PBAR P, KK    9/67
WK    S   80   56.0     25.0              BARLOW     67 HBC  +-  1.2 PBAR P, KK    9/67
WK   N        (88.)    (23.)     (22.)    BEUSCH     67 OSPK   0 5-12 PI-P,K1K1   11/71
WK       130  (90.0)                      CONFORTO   67 HBC  +-  0. PBAR P IN KK   9/67
WK             47.      18.               DAHL       67 HBC   -  2.7-4.5 PI- P     8/67
WK   N        (80.5)   (36.5)             DAHL       67 HBC    0 2.7-4.5 PI- P    11/71
WK   N        (21.0)   (10.0)    (6.0)    CRENNELL   68 HBC    0 6.0 PI-P,K1K1    11/71
WK    S 132    90.0     31.0              ALSTON     70 HBC  +  7.0 PI+P,K+KS P    1/71
WK    S 190   125.0     36.0              CRENNEL    71 HBC   - 4.5 PI- P,KSK-P   11/71
WK    S1500   123.0     13.0              GRAYER     71 ASPK  - 17.2 PI-P,K-KS P  11/71
WK      730   113.0     19.0              FOLEY      72 CNTR  - 20.3 PI- P,K- KS  12/72
WK    S2724   105.0      8.0              MARGULIES  76 CPEC  - 23.PI-P,K-KS      12/77
WK      350   110.0     18.0              HYAMS      78 ASPK +  12.7 PI+P,K+KS P   4/78*
WK    11000   126.0     11.0              CHABAUD    78 SPEC   -9.8 PI-P,K- KS P   4/78*
WK     4730   101.0      8.0              CHABAUD    78 SPEC  - 18.8PI-P,K- KS P   4/78*
WK P S        113.       4.               MARTIN 1   78 SPEC  -10 PI P,KS K- P     4/78*
WK     4000  (106.0)    (4.0)             CHABAUD    79 SPEC  - 17PI-NUCLEI,KSK-  12/79*
WK            . . . . . . . . . .
WK   AVG      108.6      4.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
WK   STUDENT  109.5      3.4     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )

WK   P    FROM A FIT TO JP=2+ PARTIAL WAVE.
WK   N   THE NEUTRAL MODE CAN INTERFERE WITH THE F MESON
WK    S  WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE

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                    12  A2 WIDTH (MEV), ETA PI MODE

W       189  103.0     20.0               ALSTON     70 HBC  +  7.0 PI+P,PI ETA    1/71
W           (120.0)                       CASO       70 HBC   - 11.2PI-P,PI ETA    5/70
W        32  (41.0)    (20.0)    (16.0)   DZIERBA    70 HBC   -  8. PI- P,PI ETA 11/70
W    T   30  (38.0)    (30.0)             JOHNSTON   70 HBC   -  7.PI-P,PI-ETA P  1/73
W            120.      30.                ESPIGAT    72 HBC  +- 0.PBAR P,ETA 2PI 11/71
W      1000  108.       9.                KEY        73 OSPK -  6.PI-P,P PI-ETA    1/74
W    M 6200 (104.)     (9.)               CONFORTO   73 OSPK -  6.PI-P,P MMS-      1/74
W            . . . . . . . . . .
W    AVG     108.1      7.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W    STUDENT 108.0      8.5     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W    M   MISSING MASS WITH ENRICHED MMS=ETA PI-, ETA = 2 GAMMA
W    T   WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE

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                    12  A2 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      A2 INTO RHO PI                                  776+ 139
P2      A2 INTO K KBAR                                  493+ 497
P3      A2 INTO ETA PI                                  548+ 139
P4      A2 INTO OMEGA PI PI                             139+ 139+ 782
P5 S    A2 INTO PI+ PI- PI0 EXCL.RHO PI                 139+ 139+ 134
P6 S    A2 INTO PI+ PI- PI- EXCL.RHO PI                 139+ 139+ 139
P7 S    A2 INTO PI GAMMA                                139+   0
P8 S    A2 INTO ETA PRIME PI                            957+ 139
P9 S    A2 INTO GAMMA GAMMA                               0+   0

P  S    SMALL, NOT USED IN THE FIT

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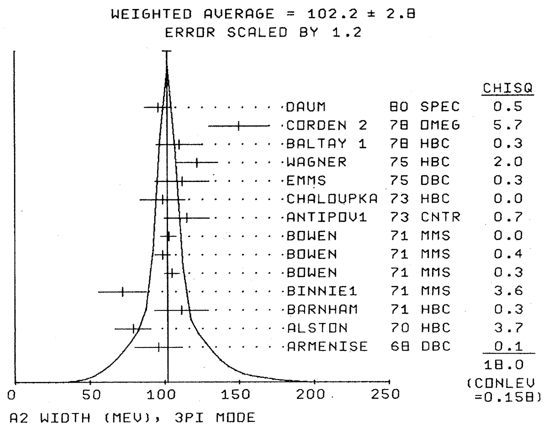

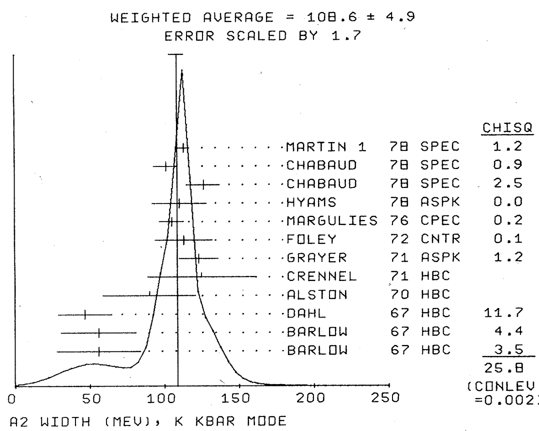

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

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        P 1          P 2         P 3         P 4
P 1  .7004+-.0217
P 2    .1210   .0479+-.0049
P 3   -.0506     -.0382   .1458+-.0114
P 4   -.8714     -.2858     -.4049   .1058+-.0250
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                    12  A2 PARTIAL WIDTHS

W1       A2 INTO GAMMA GAMMA (KEV)
W1 F          (2.5)   OR LESS CL=0.95    ABRAMS     79 SMAG    E+ E-            12/79*
W1 F       FROM RHO PI DECAY MODE
W1 D         (17.0)   OR LESS CL=0.95    ABRAMS     79 SMAG    E+ E-            12/79*
W1 D       FROM K+ K- DECAY MODE

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Data Card Listings

For notation, see key at front of Listings.

Mesons

$A_2(1310)$

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                    12  A2 BRANCHING RATIOS

R1     A2 (CHARGED ONLY) INTO (K KBAR)/(RHO PI)          (P2)/(P1)
R1  N       (0.13)   (0.03)          BEUSCH    67 OSPK   0 5,7,12 PI-+        9/67
R1  N  THE NEUTRAL MODE CAN INTERFERE WITH F.
R1    11     0.09     0.06     0.09  ASCOLI    68 HBC  -  5 PI-P              6/68
R1           0.054    0.022          CHUNG     68 HBC  -  3.2 PI-P          . 1/67
R1          (0.03)   (0.012)         DONALD    68 HBC +-  1.2 PBAR P        . 2/72
R1           0.06     0.03           ABRAMOVIC 70 HBC  -  3.93 PI- P          1/71
R1           0.07     0.03           NEF       70 MMS  -  7.0 PI- P           6/70
R1   113     0.097    0.018          ALSTON    71 HBC  +  7.0 PI+ P           1/71
R1    50     0.056    0.014          CHALOUPKA 73 HBC  - 3.9 PI- P,P A2       2/73
R1   F       0.078    0.017          CHABAUD   78 SPEC - 10,19 PI-P,KS K- 12/78*
R1   F  FROM A FIT TO ALL AVAILABLE CROSS SECTIONS AT DIFFERENT ENERGIES.
R1         . . . . . . . . .
R1  AVG      0.0699   0.0079  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT  0.0694   0.0092  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT      0.0684   0.0071 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2     A2 INTO (ETA PI)/(RHO PI + K KBAR + ETA PI)        (P3)/(P1+P2+P3)
R2    34     0.15     0.04           BARNHAM   71 HBC  + 3.7 PI+ P           11/71
R2           0.13     0.04           ESPIGAT   72 HBC +- 0.PBAR P,           11/71
R2         . . . . . . . . .
R2  AVG      0.140    0.028   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  STUDENT  0.140    0.030   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2  FIT      0.163    0.012  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3     A2 INTO (ETA PI) / (RHO PI)                        (P3)/(P1)
R3           0.3      0.2            ADERHOLZ  64 HBC     4.0 PI+P
R3           0.22     0.09           CONTE     67 HBC  -  11.0 PI-P           8/67
R3    22     0.23     0.08           ASCOLI    68 HBC  -  5 PI-P              6/68
R3           0.12     0.08           CHUNG     68 HBC  -  3.2 PI-P           12/66
R3           0.16     0.10           KEY       68 HBC  -  3 PI-P            .11/67
R3  D       (0.18)   (0.06)          VETLITSKY 69 HBC  -  3.3 PI- P           9/68
R3           0.3      0.13           ABRAMOVIC 70 HBC  -  3.93 PI- P        . 1/71
R3    15     0.25     0.09           BOCKMANN  70 HBC  +  5.0 PI+P            9/69
R3           0.34     0.17     0.34  BOCKMANN  70 HBC   0 5.0 PI+ P           9/69
R3  D  39   (0.18)   (0.07)          DZIERBA   70 HBC  -  8. PI- P           11/71
R3   167     0.246    0.042          ALSTON    71 HBC  +  7.0 PI+ P           1/71
R3   149     0.211    0.044          CHALOUPKA 73 HBC  - 3.9 PI- P,P A2       2/73
R3    52     0.22     0.05           ANTIPOV   73 CNTR - 40. PI-P,P A2-       1/74
R3           0.18     0.05           FORINO    76 HBC     11 PI- P,ETA PI    12/77
R3          (0.2)    (0.02)          GHIDINI   77 OMEG   -12 PI-P,P 3PI      12/77
R3         . . . . . . . . .
R3  AVG      0.215    0.019   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  STUDENT  0.215    0.021   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3  FIT      0.208    0.018  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4     A2 INTO (ETA PRIME PI) / TOTAL                     (P8)
R4          (0.1)  OR LESS           CHUNG     65 HBC  -  3.2 PI-P
R4          (0.02) OR LESS  CL=.97   BARNHAM   71 HBC  + 3.7 PI+ P          . 2/72

R5     A2 INTO (ETA PRIME PI)/(RHO PI)                    (P8)/(P1)
R5           0.04     0.03     0.04  BOCKMANN  70 HBC   0 5.0 PI+ P           9/69
R5  D    8  (0.15)   (0.09)          DZIERBA   70 HBC  -  8. PI- P           11/71
R5  D      STRONGLY DEPENDENT ON BACKGROUND SUBTRACTION                      11/71
R5          (0.04) OR LESS           ALSTON    71 HBC  +  7.0 PI+ P           1/71
R5          (0.011)OR LESS  CL=.90   EISENSTEI 73 HBC  - 5.PI- P,P 6PI        1/74

R6     A2 INTO (PI+ PI- PI0) / (RHO PI)                   (P5)/(P1)
R6          (0.17) OR LESS           BENSON    66 DBC   0 3.7 PI+D

R7     A2 INTO (ETA PI)/(K KBAR)                          (P3)/(P2)
R7  E       (3.0)  OR LESS           FOSTER    68 HBC  -  PBAR P,PBA REST 11/71
R7  E SUPERSEDED BY ESPIGAT 72 (SEE UNDER R2 AND R8)                         11/71

R8     A2 INTO (K KBAR)/(RHO PI + K KBAR + ETA PI)        (P2)/(P1+P2+P3)
R8    17     0.06     0.03           BARNHAM   71 HBC  + 3.7 PI+ P,KSK+P     11/71
R8  A       (0.020)  (0.004)         ESPIGAT   72 HBC +- 0.PBAR P,            2/72
R8  A   NOT AVERAGED BECAUSE OF DISCREPANCY BETWEEN MASSES
R8  A   FROM  (K KBAR)  AND  (RHO PI)  MODES
R8     8     0.03     0.02           DAMERI    72 HBC  -  11. PI- P          12/72
R8           0.05     0.02           TOET      73 HBC  +  5. PI+ P,P K+ K0 12/75
R8           0.09     0.04           TOET      73 HBC   0 5.PI+P,PI+P K KB 12/75
R8         . . . . . . . . .
R8  AVG      0.048    0.012   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  STUDENT  0.048    0.014   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R8  FIT      0.0536   0.0053 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R9     A2 INTO (PI+ PI- PI-)/(RHO0 PI-)                   (P6C)/(P1C)
R9          (0.23) OR LESS  CL=.90   ABRAMOVIC 70 HBC  -  3.93 PI- P          1/71

R11    A2 INTO (PI GAMMA)/TOTAL                           (P7)
R11 R       (0.005)  (0.005)  (0.003)EISENBERG 72 HBC     PHOTOPRODUCTION    11/71
R11R M       0.0045   0.0011         MAY       77 SPEC +- 9.7 GAM N,A2 X     12/77
R11 R   PION EXCHANGE MODEL USED IN THIS ESTIMATION
R11  M  MAY 77 GIVE PARTIAL WIDTH 460+/-110 KEV.

R12    A2 INTO (OMEGA PI PI)/(RHO PI)                     (P4)/(P1)
R12         (0.19)   (0.08)          DEFOIX    73 HBC   0 0.7 PBAR P,7 PI    12/77
R12  279     0.10     0.05           CHALOUPKA 73 HBC  - 3.9 PI- P,P A2     . 2/73
R12   60     0.28     0.09           DIAZ      74 DBC   0 6.PI+N,P(5PI)0      1/74
R12  K 140  (0.29)   (0.08)          KARSHON   74 HBC   0 4.9 PI+P,DEL++A2 12/77
R12  K  60  (.10)    (.04)           KARSHON   74 HBC  + 4.9 PI+P,P A2+      12/77
R12  K       0.18     0.08           KARSHON   74 HBC   AVG OF ABOVE TWO     12/77
R12  K  KARSHCN 74 SUGGEST AN ADDITIONAL I=0 STATE, STRONGLY COUPLED
R12  K  TO OMEGA PI PI  COULD EXPLAIN DISCREPANCIES IN BRANCHING RATIOS
R12  K  AND MASSES. WE USE A CENTRAL VALUE AND A SYST. SPREAD.
R12        . . . . . . . . .
R12 AVG      0.151    0.049   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R12 STUDENT  0.150    0.046   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R12 FIT      0.151    0.040  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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REFERENCES FOR A2


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ADERHOLZ 64 PL 10 226           (AACHEN+BERLIN+BIRM+BONN+HAMBURG+LOIC+MPIM)
CHUNG    64 PRL 12 621          +DAHL,HARDY,HESS,KALBFLEISCH,KIRZ       (LRL)
GOLDHABE 64 DUBNA CONF  1 480 G GOLDHABER,S GOLDHABER,OHALLORAN,SHEN(LRL)
LANDER   64 PRL 13 346          +ABOLINS,CARMONY,HENDRIKS,XUONG+ (LA JOLLA)

ABCLINS  65 ATHENS(OHIO)CONF. +CARMONY,LANDER,XUONG,YAGER      (LA JOLLA)I=1
ADERHOLZ 65 PR 138 B 897           (AACHEN+BERL+BIRM+BONN+HAMB+LOIC+MPIM)
ALITTI   65 PL 15 69            ALITTI,BATON,DELER,CRUSSARD+  (SACLAY+BGNA)  JP
CHUNG    65 PRL  15  325        +DAHL,HARDY,HESS,JACOBS,KIRZ,MILLER   (LRL)
FORINO   65 PL 19 68            +GESSAROLI+       (BGNA+BARI+FIRZ+ORSA+SACL)
LEFEBVRE 65 PL 19 434           CERN MISSING MASS SPECTROMETER GROUP (CERN)
SEIDLITZ 65 PRL 15 217          L SEIDLITZ,O I DAHL,D H MILLER        (LRL)

BARNES   66 PRL 16 41           BARNES,FOWLER,LAI,ORENSTEIN +    (BNL+CUNY)
BENSON   66 MICH CCO-1112-4     G.C.BENSON, THESIS                    (MICH)
   ALSO  66 PRL 16 1177         G BENSON,LOVELL,MARQUIT,ROE  +        (MICH)
EHRLICH  66 PR 152 1194         R. EHRLICH,W.SELOVE, H.YUTA           (PENN)
FERBEL   66 PL 21 111           FERBEL                           (ROCHESTER)
LEVRAT   66 PL  22  714         CERN MISSING MASS SPECTROMETER GROUP (CERN)

ARMENISE 67 PL 25B 53           ARMENISE,FORINO,+     (BARI+BGNA+FIRZ+ORSAY)
BALTAY   67 PL 25B 160          +KIRSCH+KUNG+YEH+RABIN    (COLU+BNL+RUTGERS)
BARLOW   67 NC 50A 701          +LILLESTOL+MONTANET+  (CERN+CDEF+IRAD+LIVP)
BARTSCH  67 PL 25B 48           +DEUTSCHMANN+GROTE+COCCONI+(AACH+BERL+CERN)
BEUSCH   67 PL 25 B 357         +FISCHER,GOBBI,ASTBURY+           (ETH+CERN)
CASON    67 PRL 18 880          +LAMSA,BISWAS,DERADO,GROVES,+   (NOTREDAME)
CHIKOVAN 67 PL 25B 44           CERN MISSING MASS SPECTROMETER GROUP (CERN)
CHUNG    67 PRL 18 100          +DAHL,HARDY,HESS,KIRZ,MILLER           (LRL)
    ALSO 66 UCRL-16832          RICHARD I HESS--THESIS,BERKELEY        (LRL)
COHN     67 NP B1 57            +MCCULLOCH+BUGG+CONDO       (ORNL+UNIV.TENN.)
CCNFORTO 67 NP B3 469           +MARECHAL,MCNTANET+     (CERN+CDEF+IPN+LIVP)
CONTE    67 NC  51 A  175       +TOMASINI,CORDS+(GENOVA+HAMB+MILANO+SACLAY)
DAHL     67 PR 163 1377         +HARDY+HESS+KIRZ+MILLER                (LRL)
DANYSZ   67 NC 51 A 801         DANYSZ+FRENCH+SIMAK                   (CERN)
SLATTERY 67 NC 50A 377          +KRAYBILL+FORMAN+FERBEL         (YALE+ROCH)  JP

ARMENISE 68 PL 26B 336          ARMENISE,FORINO,+     (BARI+BGNA+FIRZ+ORSAY)
ASCOLI   68 PRL 20  1321        +CRAWLEY,MCRTARA,SHAPIRC,BRIDGES+(ILLINOIS)  JP
BALLAM   68 PRL 21 934          +BRODY,CHADWICK,FRIES,GUIRAGOSSIAN+  (SLAC)
BENZ     68 PL 28 B 233         CERN MISSING MASS SPECTROMETER GROUP (CERN)
BOESEBEC 68 NP B 4 501          BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO     68 NC 54 A 983         +CONTE+CORDS+DIAZ+ (GENOVA+HAMB+MILAN+SACL)
CHUNG    68 PR 165 1491         S.U.CHUNG,O.DAHL,J.KIRZ,D.H.MILLER     (LRL)
CRENNELL 68 PRL 20 1318         +KARSHON+KWAN LAI,SCARR,SKILLICORN     (BNL)
DONALD   68 PL 26 B  327        +FRODESEN+BETTINI+   (LIVERPOOL+OSLO+PADUA)
FOSTER   68 NP B 8 174          +GAVILLET,LABROSSE,MONTANET,+   (CERN+CDEF)
FRIDMAN  68 PR 167 1268         +MAURER,MICHALON,OUDET+(HEID   +STRASBOURG)
JUNKMANN 68 NP B8 471           +COCCONI,+         (AACH+BERL+BONN+CERN+WARS)
KEY      68 PR 166 1430         +PRENTICE+COOPER+MANNER+     (TNTO+ANL+WISC)
LAMSA    68 PR 166 1395         +CASON+BISWAS+DERADO+GROVES+     (NOTREDAME)
VON KROG 68 PL 27 B 253         +MIYASHITA,KOPELMAN,MARSHALL LIBBY    (COLO)

ADERHOLZ 69 NP B 11 259         +BARTSCH,+         (AACH+BERL+CERN+JAGL+WARS)
AGUILAR 169 PL 29 B  62         +BARLOW,JACOBS,DELLA NEGRA+(CERN+CDEF+LIVP)
AGUILAR 269 PL 29 B  241        M.AGUILAR-BENITEZ,J.BARLOW,+    (CERN+CDEF)
ANDERSON 69 PRL 22 1390         +COLLINS,+                        (BNL+CARN)
ARMENISE 69 LNC 2 501           +GHIDINI,FORINO,CARTACCI+  (BARI+BGNA+FIRZ)
CHIKOVAN 69 PL 28 B  526        CERN MISSING MASS SPECTROMETER GROUP (CERN) JP
CRENNELL 69 PRL 22 1327         +KARSHON,KWAN WU LAI,+                (BNL)IJP
DONALD   69 NP B 12 325         +EDWARDS,FOSTER,MOORE            (LIVERPCOL)
EISENBER 69 PRL 23 1322         EISENBERG,HABER,BALLAM,CHADWICK+(REHO+SLAC)
VETLITSK 69 SJNP 9 596          VETLITSKY,GRIGOREYEV,GRISHIN,+        (ITEP)

ABRAMOVI 70 NP B 29 466         ABRAMOVICH,BLUMENFELD,BRUYANT,+       (CERN)  JP
ALSTCN   70 PL 33 B 607         +BARBARO,BUHL,DERENZO,EPPERSON,FLATTE+(LRL)
ASCOLI   70 PRL 25 962          +BROCKWAY,CRAWLEY,EISENSTEIN,HANFT,+  (ILL)  JP
BASILE   70 LNC 4 838           +DALPIAZ,FRABETTI,MASSAM,+ (CERN+BGNA+STRB)
BAUD1    70 PL 31B  397         CERN BOSON SPECTROMETER GROUP          (CERN)
BAUD2    70 PHILAD.CONF.P.311 CERN BOSON SPECTROMETER GROUP          (CERN)
BAUD3    70 PL 31 B 401         CERN BOSON SPECTROMETER GROUP          (CERN)
BOCKMANN 70 NP B 16 221         +MAJOR,POLS,+      (BONN+DURH+NIJM+EPOL+TORI)
BUTLER   70  UCRL 19845         THESIS                                  (LRL)
CAROLL   70 PRL 25 1393         +FIREBAUGH,GARFINKEL,MORSE,OH,+ (WISC+TNTO)
CASO     70 LNC 3 707           +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
DIAZ     70 NP B 16 239         +GAVILLET,LABROSSE,MONTANET+     (CERN+CDEF)JP
DZIERBA  70 PR D 2 2544         +SHEPHARD,BISWAS,CASON,JOHNSON,KENNEY(NDAM)
   ALSO  68 LAMSA
GARFINKE 70 PL 33 B 536         GARFINKEL,AMMANN,CARMCNY,YEN        (PURD)JPC
JOHNSTON 70 NP B 24 253         +KEY,PRENTICE,YOON,GARFINKEL,+   (TNTO+WISC)
KRUSE    70 PHILAD.CONF.P.359 U.KRUSE, PARTIAL WAVE ANALYSIS           (ILL)  JP
NEF      70  THESIS+PRIV.COMM.CERN BOSCN SPECTROMETER GROUP             (CERN)
SUTHERLA 70 PHILAD.CCNF.P.369 G.SUTHERLAND,INTERFERING RESONANCE(GLASGOW)

AGUILAR  71 PR D 4 2583         AGUILAR-BENITEZ,EISNER,KINSON           (BNL)
ALSTCN   71 PL 34 B 156         +BARBARO,BUHL,DERENZO,EPPERSON,FLATTE+(LRL)
BARNHAM  71 PRL 26 1494         +ABRAMS,BUTLER,COYNE,GOLDHABER,HALL,+ (LBL)
BEKETOV  71 SJNP 4 765          +SOMBKOWSKY,KONOWALOV,KRUTSCHININ,+  (ITEP). JP
BINNIE1  71 PL 36 B 257         +CAMILLERI,DUANE,FARUQI,BURTON,+(LOIC+SHMP)
BINNIE2  71 PL 36 B 537         +CAMILLERI,DUANE,FARUQI,BURTON,+(LOIC+SHMP)
BOWEN    71 PRL 26 1663         +FARLES,FAISSLER,BLIEDEN,+        (NEAS+STON)
CRENNEL  71 PL 35 B 185         +GORDON,KWAN-WU LAI,SCARR               (BNL)
FARBER   71 NP B 29 237         +DE PINTO,BISWAS,CASCN,DEERY,KENNEY,+(NDAM)
FOLEY    71 PRL 26 413          +LOVE,OZAKI,PLATNER,LINDENBAUM,+ (BNL+CUNY)
GRAYER   71 PL 34 B 333         +HYAMS,JCNES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
LYNCH    71 UCRL 20022 AND 71 AMSTERDAM CONF.  G.LYNCH                  (LBL)
RINAUDO  71 NC 5 A 239          +BOECKMANN,MAJOR+(TORI+BONN+DURH+NIJM+EPOL) JP

ANKENBRA 72 PRL 29 1688         ANKENBRANDT,BRABSON,CRITTENDEN,HEINZ,+(IND)
BERENYI  72 NP B 37 621         +PRENTICE,STEENBERG,YOON,WALKER (TNTO+WISC)
BLOODWOR 72 NP B 37 203         BLOODWORTH,JACKSON,PRENTICE,YOON       (TNTO)
DAMERI   72 NC 9 A 1            +BORZATTA,GCUSSU,+             (GENO+MILA+SACL)
DIEBOLD  72  BATAV.CONF.        R.DIEBOLD  RAPPORTEUR TALK              (ANL)
EISENBER 72 PR D 5 15           EISENBERG,BALLAM,DAGAN,+    (REHO+SLAC+TELA)
ESPIGAT  72 NP B 36 93          +GHESQUIERE,LILLESTOL,MCNTANET   (CERN+CDEF)
FOLEY    72 PR D 6 747          +LOVE,OZAKI,PLATNER,LINDENBAUM,+ (BNL+CUNY)
LASSILA  72 PRL 28 1491         LASSILA,YOUNG                          (IOWA)
MORSE    72 NP B 43 77          +OH,WALKER,JOHNSTON,YOON          (WISC+TNTO)

AMMANN   73 PR D 7 1345         +CARMONY,GARFINKEL,GUTAY,MILLER+(PURD+IUPU)
ANKEBRAN 73 PR D 8 2785         ANKEBRANDT,BRABSON,CRITTENDEN,HEINZ,+ (IND)
ANTIPOV  73 NP B 63 175         +ASCOLI,BUSNELLO,FOCACCI,+        (CERN+SERP)  JP
ANTIPOV1 73 NP B 63 153         +ASCOLI,BUSNELLO,FOCACCI,+        (CERN+SERP)  JP
ANTIPOV2 73 NP B 63 141         +ASCOLI,BUSNELLO,FOCACCI,+        (CERN+SERP)  JP
CASON    73 NP B 64 14          +MADDEN,BISHOP,BISWAS,KENNEY,+         (NDAM)
CHALOUPK 73 PL 44 B 211         CHALOUPKA,DOBRZYNSKI,FERRANDO,LOSTY,+(CERN)
CONFORTO 73 PL 45 B 154         +MOBLEY,KEY,PERPOST,+  (EFI+FNAL+TNTO+WISC)
DEFOIX   73 PL 43 B 141         +DOBRZYNSKI,ESPIGAT,NASCIMENTO,+       (CDEF)
EISENSTE 73 PR D 7 278          EISENSTEIN,SCHULTZ,ASCOLI,IOFFREDO,+  (ILL)
KEY      73 PRL 30 503          +CONFORTO,MOBLEY,+       (TNTO+EFI+FNAL+WISC)
TOET     73 NP B 63 248         +THUAN,MAJOR,RINAUDO,+(NIJM+BONN+DURH+TORI)

DIAZ     74 PRL 32 260          +DIBIANCA,FICKINGER,ANDERSON,+  (CASE+CARN)
KARSHCN  74 PRL 32 852          +MIKENBERG,PITLUCK,EISENBERG,RONAT+  (REHO)
OTTER    74 NP B80 1            +RUDOLPH+          (AACH+BERL+BONN+CERN+HEID)  JP
TABAK    74  BOSTON P. 46       +RONAT,ROSENFELD,LASINSKI+        (LBL+SLAC)  JP
THOMPSO1 74 PR D9 560           THOMPSON,GAIDOS,MCILWAIN,WILLMANN      (PURD)  JP
THOMPSO2 74 NP B69 381          THOMPSON,BADEWITZ,GAIDOS,MCILWAIN+     (PURD)  JP

ABASHIAN 75 PRL 34 691          +BEAMER,BROSS,EISENSTEIN,+     (ILL+ANL+ISU)
EMMS     75 PL 58B 117          +JONES,KINSON,STACEY,BELL+ (BIRM+DURH+RHEL)  JP
LOSTY    75 PL 56B 96           +CHALOUPKA,MONTANET,GANDOIS+     (CERN+SACL)  JP
UNDERWOO 75 PR D11 2345         UNDERWOOD,CONFORTO,KEY+(EFI+FNAL+TNTO+WISC)
    ALSO 73 CCNFORTO, 73 KEY
WAGNER   75 PL 58B 201          +TABAK,CHEW                              (LBL)  JP

FORINO   76 NC A 35 465         +GESSAROLI,+  BGNA+FIRZ+GENO+MILA+OXF+PAV
HANDLER  76 NP B 110 173        +PLANO,BRUCKNER,KOLLER,,+  (RUTG,STEV,SETO)
MARGULIE 76 PR D 14 667         +KRAMER,FOLEY,LOVE,LINDENBAUM,+  (BNL+CUNY)

CERRADA  77 NP B 126 241        +BLOCKZIJL,HEINEN,+      (AMST+CERN+NIJM+OXF)
GHIDINI  77  PREPRINT           +              (BARI+BONN+CERN+DARE+LIVP+MILA)  JP
MAY      77 PR D 16 1983        +ABRAMSON,ANDREWS,BUSNELLO,+      (ROCH+CCRN)
PAWLICKI 77 PR D 15 3196        +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND   (ANL)I J
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Mesons

A_2(1310), E(1420), X(1410–1440), f′(1515)

Data Card Listings

For notation, see key at front of Listings.


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BALTAY 1 78 PR D 17 62        +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
BALTAY 2 78 PRL 40 87         +CAUTIS,KALELKAR                      (COLU)  JP
CHABAUD  78 NP B 145 349      +HYAMS,JONES,WEILHAMMER,BLUM,+  (CERN+MPIM)
CORDEN 1 78 NP B 136 77       DOWELL,GARVEY,JOBES+  (BIRM+RHEL+TELA+LOWC)  JP
CORDEN 2 78 NP B 138 235      +CORBETT,ALEXANDER,+  (BIRM+RHEL+TELA+LCWC)
FERRER   78 PL 74 B 287       +TREILLE,RIVET +     (ORSAY+CERN+CDEF+LPNP)
HYAMS    78 NP B 146 303      +JONES,WEILHAMMER,BLUM,+   (CERN+MPIM+ATEN)
MARTIN 1 78 PL 74 B 417       +OZMUTLU+BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)  JP
MARTIN 2 78 NP B 140 158      +OZMUTLU,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)

ABRAMS   79  SLAC-PUB 2421    +ALAM,BLOCKER,BOYARSKI,+            (SLAC+LBL)
CHABAUD  79  CERN/EP 79-159   +HYAMS,PAPADOPOULOU,+          (CERN+MPIM+AMST)

DAUM     80 PL 89 B 276       +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)  JP
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E(1420)

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6  E(1420,JPG=1++) I=0
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                       6  E MASS (MEV)

M           1425.       7.             BAILLON   67 HBC    0. PBAR P        11/66
M           1420.      20.             DAHL      67 HBC    1.6-4.2 PI- P     9/66
M           1423.0     10.0            FRENCH    67 HBC     3-4 PBAR P       6/67
M       310 1420.       7.             LORSTAD   69 HBC    .7PB P,4,5-BODY   9/69
M       170 1398.      10.             DEFOIX    72 HBC    0.7 PBAR P,7 PI   1/73
M       280 1406.       7.             DUBOC     72 HBC    1.2 PBAR P,2K4PI 12/72
M        36(1397.0)    (10.0)          CORDEN    78 OMEG   12-15PI-P,K+K-PI  4/78*
M           1417.5      4.             NACASCH   78 HBC     .7,.76 PBAR P  . 4/78*
M       221 1426.0      6.0            DIONISI   80 HBC    4. PI-P,K K PI N 12/79*
M           . . . . . . . . . .
M    AVG    .1417.9     2.9      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
M    STUDENT1418.3      2.8      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                       (SEE IDEOGRAM BELOW )
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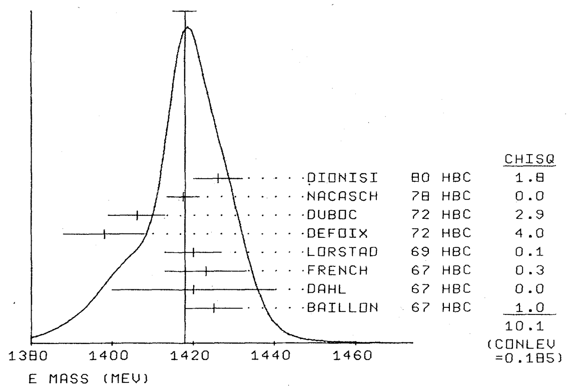
WEIGHTED AVERAGE = 1417.9 ± 2.9
ERROR SCALED BY 1.2

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                       6  E WIDTH (MEV)

W           80.        10.             BAILLON   67 HBC    0. PBAR P        11/66
W           60.0       20.0            DAHL      67 HBC    1.6-4.2 PI- P    10/66
W           45.        20.             FRENCH    67 HBC     3-4 PBAR P       6/67
W      310  60.        20.             LORSTAD   69 HBC    .7PB P,4,5-BODY   9/69
W      170  50.        10.             DEFOIX    72 HBC    0.7 PBAR P,7 PI   1/73
W      280  50.        12.             DUBOC     72 HBC    1.2 PBAR P,2K4PI 12/72
W       36 (45.0)     (30.0)           CORDEN    78 OMEG   12-15PI-P,K+K-PI  4/78*
W           53.        20.0            NACASCH   78 HBC     .7,.76 PBAR P  . 4/78*
W      221  40.0       15.0            DIONISI   80 HBC    4. PI-P,K K PI N 12/79*
W           . . . . . . . . . .
W    AVG    57.3        5.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
W    STUDENT 55.5       6.0      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                       6  E PARTIAL DECAY MODES

                                                           DECAY MASSES
P1     E INTO K K*(892)                                   497+ 892
P2     E INTO K KBAR PI                                   497+ 497+ 139
P3     E INTO PI PI RHO                                   134+ 134+ 776
P4     E INTO DELTA PI                                    981+ 139
P5     E INTO ETA PI PI                                   548+ 139+ 139
P6     E INTO 4 PI                                        139+ 139+ 139+ 139

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                       6  E BRANCHING RATIOS

R1     E INTO (KBAR K*(892) + C.C.)/(K KBAR PI)         (P1)/(P2)
R1   M        .50        .10          BAILLON   67 HBC     0.0 PBAR P       12/78*
R1   N       0.86       0.12          DIONISI   80 HBC    4. PI-P,K K PI N 12/79*
R1   M  FROM JP=0- SOLUTION
R1   N  FROM JP=1+ SOLUTION
R1            . . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)

R2     E INTO (PI PI RHO) / (K KBAR PI)                 (P3)/(P2)
R2           (2.0)  OR LESS               DAHL      67 HBC    0  1.6-4.2 PI- P .10/66
R2           (0.3)  OR LESS  CL=.95       CORDEN    78 OMEG    12-15PI-P          4/78*

R3     E INTO (ETA 2 PI)/(K KBAR PI)                    (P5)/(P2)
R3           (1.5)  OR LESS  CL=.95       FOSTER    68 HBC   - 0.0 PBAR P         9/69
R3            1.5       0.8               DEFOIX    72 HBC     0.7 PBAR P         1/73
R3           (0.5)  OR LESS  CL=.95       CORDEN    78 OMEG    12-15PI-P          4/78*

R4     E INTO (DELTA PI)/(ETA PI PI)                    (P4)/(P5)
R4          0.4       0.2               DEFOIX    72 HBC    0.7 PBAR P,7 PI   1/73
R4          NOT SEEN IN EITHER MODE CORDEN    78 OMEG    12-15PI-P         4/78*

R5     E INTO (4PI)/(KBAR K*(892) +C.C.)                (P6)/(P1)
R5          (0.90)OR LESS CL=.95      DIONISI   80 HBC    4. PI-P,K K PI N 12/79*

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REFERENCES FOR E


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BAILLON  67 NC 50A  393      +EDWARDS+D-ANDLAU+ASTIER+  (CERN+CDEF+IRAD)
BARASH   67 PR 156  1399     BARASH,KIRSCH,MILLER,TAN           (COLUMBIA)
DAHL     67 PR 163 1377      +HARDY+HESS+KIRZ+MILLER                (LRL)I JP
   ALSO  65 PRL 14 1074      MILLER,CHUNG,DAHL,HESS,HARDY,KIRZ+(LRL+UCB)
FRENCH   67 NC 52A 438       +KINSON+MCDONALD+RIDDIFORD+       (CERN+BIRM)

FOSTER   68 NP B 8 174       +GAVILLET,LABROSSE,MONTANET,+     (CERN+CDEF)
BETTINI  69 NC 62 A 1038     +CRESTI,LIMENTANI,BERTAUZA,BIGI+(PADO+PISA)IC
LORSTAD  69 NP B 14 63       B.LORSTAD,D-ANDLAU,ASTIER,+       (CDEF+CERN)  JP
DEVONS   71 PRL 27 1614      +KOZLOWSKI,HORWITZ,+              (COLU+SYRA)

CHAPMAN  72 NP B 42 1        +CHURCH,LYS,MURPHY,RING,VANDER VELDE (MICH)
DEFOIX   72 NP B 44 125      +NASCIMENTO,BIZZARRI,+            (CDEF+CERN)
DUBOC    72 NP B 46 429      +GOLDBERG,MAKOWSKI,DONALD,+       (LPNP+LIVP)

VUILLEMI 75 LNC 14 165       VUILLEMIN,+        (LAUS+NEUC+LPNP+LIVP+GLAS)  JP

HANDLER  76 NP B 110 173     +PLANO,BRUCKER,KOLLER+      (RUTG+STEV+SETO)
VUILLEMI 76 NC 33A 133       +VUILLEMIN,+       (LAUS+NEUC+LPNP+LIVP+GLAS)

EDWARDS  77  PREPRINT        +LEGACEY+(OTTAWA+MONTREAL+COLUMBUS+TORONTO)
GRASSLER 77 NP B 121 189     +(AACHEN+BERLIN+BONN+CERN+CRACOW+HEID+WARS)

CORDEN   78 NP B 144 253     +CORBETT,ALEXANDER,+  (BIRM+RHEL+TELA+LOWC)
IRVING   78 NP B 139 327     A.C.IRVING,H.R.SEPANGI                 (LIVP)
NACASCH  78 NP B 135 203     +DEFOIX,DOBRZYNSKI,+     (PARIS+MADRID+CERN)

STANTON  79 PRL 42 346       +BROCKMAN,DANKOWYCH,+  (OSU+CARL+MCGI+TNTO)  JP

DIONISI  80  CERN/EP 80-1    +GAVILLET,ARMENTEROS+ (CERN+MACR+CDEF+STOH)I,JP
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X(1410–1440)

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38  X(1410-1440)

THIS ENTRY LIST PEAKS OF LOW STATISTICAL
SIGNIFICANCE, SEEN IN RHOO RHOO OR K KBAR.
OMITTED FROM TABLE.

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                    38  X(1410-1440) MASS (MEV)

M    -------RHOO RHOO MODE-------
M         (1410.0)                     BETTINI    66 DBC   0 0. PBAR N,5 PI     2/74
M    -------KS KS MODE ----------
M    B    POSSIBLY SEEN                ABRAMS     67 HBC     4.25 K- P          5/67
M    B    THE AUTHORS ASSOCIATE THE PEAK WITH THE F PRIME, BUT BACKGROUND
M    B    ESTIMATION IS DIFFICULT
M         1412.       23.              BARLOW     67 HBC     1.2 PBAR P         5/67
M         1439.0       5.0      6.0    BEUSCH     67 OSPK    5,7,12 PI-P        9/67
M        (1425.0)                      FOLEY      71 CNTR  - 20.3 PI- P,K- KS   2/71
M        (1405.)                       DEFOIX     73 HBC   0 0.7 PBAR P,7 PI    1/74
M         . . . . . . . . . .
M    AVG     1437.5    5.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    STUDENT1437.7     5.9     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    38  X(1410-1440) WIDTH (MEV)
W    -------RHOO RHOO MODE-------
W          (90.0)                      BETTINI    66 DBC   0 0. PBAR N,5 PI     2/74

W    -------KS KS MODE ----------
W          100.       70.              BARLOW     67 HBC     1.2 PBAR P         5/67
W           43.0      17.0     18.0    BEUSCH     67 OSPK    5,7,12 PI-P        9/67
W          (20.0)  OR LESS             FOLEY      71 CNTR  - 20.3 PI- P,K- KS   2/71
W          (40.)                       DEFOIX     73 HBC   0 0.7 PBAR P,7 PI    1/74
W         . . . . . . . . . .
W    AVG       46.4   17.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W    STUDENT   46.2   18.5     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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REFERENCES FOR X(1410-1440)


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BETTINI  66 NC 42A 695       +CRESTI,LIMENTANI,LORIA,PERUZZO+(PADO+PISA)
ABRAMS   67 PRL 18 620       +KEHOE,GLASSER,SECHI-ZORN,WOLSKY (MARYLAND)
BARLOW   67 NC  50 A  701    +MONTANET,D-ANDLAU+   (CERN+CDEF+IRAD+LIVP)
BEUSCH   67 PL 25 B 357      +FISCHER,GOBBI,ASTBURY+             (ETH+CERN)
DONALD   69 NP B 11 551      +EDWARDS,BURAN,BETTINI,+    (LIVP+OSLO+PADO)
FOLEY    71 PRL 26 413       +LOVE,OZAKI,PLATNER,LINDENBAUM,+ (BNL+CUNY)
DEFOIX   73 PL 43 B 141      +DOBRZYNSKI,ESPIGAT,NASCIMENTO,+       (CDEF)
POLYCHRO 79 PR D 19 1317     POLYCHRONAKOS,CASON,BISHOP+        (NDAM+ANL)
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f′(1515)

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13  F PRIME(1515,JPG=2++) I=0
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                   13  F PRIME MASS (MEV)

M   P   14(1480.0)                   CRENNELL   66 HBC      6.0 PI- P          8/66
M   B    5(1460.)     (10.)          ABRAMS     67 HBC    4.25 K- P,KS KS      5/67
M   B   BACKGROUND ESTIMATION DIFFICULT.                                       5/67
M   P      (1515.0)    (7.0)         AMMAR      67 HBC     5.5 K-P,K KBAR      9/67
M   P  100(1519.)      (7.)          AGUILAR    72 HBC    3.9,4.6 K-,K KB     12/72
M   P   46(1514.)      (4.)          COLLEY     72 HBC    10.K+ P,K+ K-       12/72
M   P   47(1521.)      (7.)          VIDEAU     72 HBC    4.K- P,K KBAR       12/72
M  EP  120(1527.0)     (6.0)         BRANDENBU  76 ASPK   13.K-P,K+K-          7/77
M      123 1522.0       6.0          BARREIRO   77 HBC    4.15 K-P,KS KS       7/77
M      166 1528.        7.           EVANGELIS  77 OMEG   10 K- P             12/77
M    C       1506.0     5.0          PAWLICKI   77 SPEC   6.PI N,K+K-         12/77
M    N     (1502.0)   (25.0)         CORDEN     79 OMEG   12-15PI-P, N 2PI    12/79*
M          (1492.0)   (29.0)         GORLICH    79 ASPK  0 17 PI- P,POLARIZ   12/79*
M          . . . . . . . . . .
M    AVG    1516.1      6.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
M    STUDENT1517.1      4.9     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                       (SEE IDEOGRAM BELOW )
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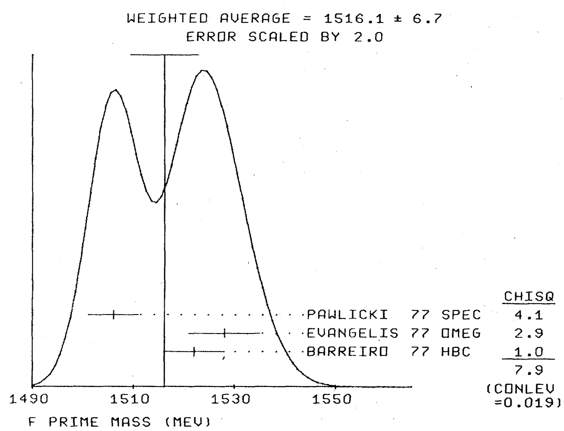
Data Card Listings

For notation, see key at front of Listings.

Mesons

f′(1515), F_1(1540), ρ′(1600)

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M    C   WITH A PHASE SHIFT ANALYSIS
M  E     MASS  ERRORS ENLARGED BY US TO   WIDTH/SQRT(N),SEE K* TYPED NOTE.
M     N  FROM AN AMPLITUDE ANALYSIS WHERE THE F PRIME WIDTH AND
M        ELASTICITY ARE IN COMPLETE DISAGREEMENT WITH VALUES
M        OBTAINED FROM KKBAR CHANNEL MAKING THE SOLUTICN DUBIOUS.
M    P   F-A2-F PRIME INTERFERENCE IN K+K- FINAL STATE NOT ACCOUNTED FOR.

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                        13  F PRIME WIDTH (MEV)

W  B    5  (53.)    (18.)              ABRAMS    67 HBC    4.25 K- P,KS KS   5/67
W  B   BACKGROUND ESTIMATION DIFFICULT.                                      5/67
W  P        (35.0)   (25.0)            AMMAR     67 HBC     5.5 K-P, K KBAR  9/67
W  P  100  (69.)    (22.)              AGUILAR   72 HBC    3.9,4.6 K-P,K KB 12/72
W  P   46  (28.)    (15.)              COLLEY    72 HBC    10.K+ P,K+ K-    12/72
W  EP  47  (40.)    (20.)              VIDEAU    72 HBC    4.K- P,K KBAR    12/72
W  EP 120  (61.0)   (22.0)             BRANDENBU 76 ASPK   13.K-P,K+K-       7/77
W     123   62.0     19.0      14.0    BARREIRO  77 HBC    4.15 K-P,KS KS    7/77
W     166   72.0     25.0              EVANGELIS 77 OMEG   10 K- P          12/77
W   C       66.0     10.0              PAWLICKI  77 SPEC   6.PI N,K+K-      12/77
W   N     (165.0)   (42.0)             CORDEN    79 OMEG   12-15PI-P, N 2PI 12/79*
W         (150.0)   (83.0)    (50.0)   GORLICH   79 ASPK 0 17 PI- P,POLARIZ 12/79*
W   M       92.0     39.0      22.0    POLYCHRON 79 STRC   7. PI-P,KS KS N  12/79*
W            . . . . . . . . . .
W  AVG      67.4      7.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W  STUDENT  67.3      8.4      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W    C   WITH A PHASE SHIFT ANALYSIS
W  E     WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE.
W     M  FROM A FIT TO THE D WAVE WITH F-F PRIME INTERFERENCE. MASS FIXED
W     M  AT 1516 MEV.
W     N  FROM AN AMPLITUDE ANALYSIS WHERE THE F PRIME WIDTH AND
W        ELASTICITY ARE IN COMPLETE DISAGREEMENT WITH VALUES
W        OBTAINED FROM KKBAR CHANNEL MAKING THE SOLUTICN DUBIOUS.
W    P   F-A2-F PRIME INTERFERENCE IN K+K- FINAL STATE NOT ACCOUNTED FOR.

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                        13  F PRIME PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      F PRIME INTO PI  PI                              139+ 139
P2      F PRIME INTO K KBAR                              497+ 497
P3      F PRIME INTO K K*(892)                           493+ 892
P4      F PRIME INTO ETA ETA                             548+ 548
P5      F PRIME INTC PI PI ETA                           139+ 139+ 548
P6      F PRIME INTO PI K KBAR                           139+ 497+ 497
P7      F PRIME INTO PI+ PI+ PI- PI-                     139+ 139+ 139+ 139
P8      F PRIME INTO GAMMA GAMMA                           0+   0

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                        13  F PRIME PARTIAL WIDTHS                        12/78*

W1      F PRIME INTO GAMMA GAMMA (KEV)                                    12/78*

W1 B          (1.2)  OR LESS CL=0.95   ABRAMS    79 SMAG    E+ E-         12/79*
W1 B     USING BRANCHING RATIO F PRIME INTO K KBAR = 1.                   12/78*

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                        13  F PRIME BRANCHING RATIOS

R1      F PRIME INTO (PI PI)/TOTAL                           (P1)
R1 C          (0.0086) OR LESS          BEUSCH    75 OSPK    8.9 PI-P,KO KO N 12/77
R1            (0.063)OR LESS  CL=0.90   BRANDENBU 76 ASPK    13.K-P,K+K-       7/77
R1            (0.045)OR LESS  CL=0.95   BARREIRO  77 HBC     4.15 K-P,KS KS    7/77
R1 C           0.012      0.004         PAWLICKI  77 SPEC    6.PI N,K+K-      12/77
R1   N        (0.19)    (0.03)          CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79*
R1 C          (0.027)   (0.071)  (0.013)GORLICH   79 ASPK  0 17,18 PI-P POLAR 12/79*
R1 C D         0.0075     0.0025        MARTIN    79 RVUE                     12/79*
R1 C     ASSUMING THAT THE F PRIME IS PRODUCED BY AN OPE
R1       PRODUCTION MECHANISM.
R1   D   MARTIN 79 USES THE PAWLICKI 77 DATA WITH DIFFERENT INPUT
R1       VALUE OF THE F INTO K KBAR BRANCHING RATIO.
R1            . . . . . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R3      F PRIME INTC (ETA ETA)/(K KBAR)                      (P4)/(P2)
R3            (0.50) OR LESS            BARNES    67 HBC       4.6, 5.0 K- P   10/67

R4      F PRIME INTO (PI PI ETA)/(K KBAR)                    (P5)/(P2)
R4            (0.3)  OR LESS  CL=.67    AMMAR     67 HBC                       10/67
R4  A         (0.25)    (0.13)          BARNES    67 HBC       4.6, 5.0 K- P   10/67
R4  A    SUPERSEDED BY AGUILAR 72
R4            (0.41) OR LESS  CL=.95    AGUILAR   72 HBC      3.9,4.6 K- P     12/72

R5      F PRIME INTO (PI K KBAR + K K*(892))/(K KBAR)        (P6+P3)/(P2)
R5            (0.4)  OR LESS  CL=.67    AMMAR     67 HBC                       10/67
R5            (0.35) OR LESS  CL=.95    AGUILAR   72 HBC      3.9,4.6 K- P     12/72

R6      F PRIME INTO (PI+ PI+ PI- PI-)/(K KBAR)              (P7)/(P2)
R6            (0.32) OR LESS  CL=.95    AGUILAR   72 HBC      3.9,4.6 K- P     12/72

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                        REFERENCES FOR F PRIME

BARNES   65 PRL 15 322          +CULWICK,GUIDONI,KALBFLEISCH,GOZ+(BNL+SYRA)

CRENNELL 66 PRL  16  1025       + KALBFLEISCH,LAI,SCARR,SCHUMANN +     (BNL)I

ABRAMS   67 PRL 18 620          +KEHOE,GLASSER,SECHI-ZORN,WOLSKY (MARYLAND)
AMMAR    67 PRL  19  1071       +DAVIS,HWANG,DAGAN,DERRICK +     (NWES+ANL)  JP
BARNES   67 PRL  19  964        +DORNAN,GOLDBERG,LEITNER +   (BNL+SYRACUSE)ICJP
ALITTI   68 PRL 21 1705         +BARNES,CRENNELL,FLAMINIO,GOLDBERG,+  (BNL)

LORSTAD  69 NP B 14 63          B.LORSTAD,D-ANDLAU,ASTIER,+      (CDEF+CERN)
SCOTTER  69 NC 62 A 1057        +ERSKINE,PALER,+  (BIRM+GLAS+LOIC+MPIM+OXF)

AGUILAR  72 PR D 6 29           AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS   (BNL)
COLLEY   72 NP B 50 1           +JOBES,RIDDIFORD,GRIFFITHS,+     (BIRM+GLAS)
VIDEAU   72 PL 41 B 213         +VIDEAU,ROUGE,BARRELET,DEBRION,+(EPOL+SACL)

BEUSCH   75 PL 60 B 101         +BIRMAN,WEBSDALE,WETZEL            (CERN+ETH)

BRANDENB 76 NP B 104 413        BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)

BARREIRO 77 NP B 121 237        +DIAZ,GAY,HEMINGWAY,+  (CERN+AMST+NIJM+OXF)
EVANGELI 77 NP B 127 384        EVANGELISTA,+    (BARI+BCNN+CERN+DARE+GLAS+)
LAVEN    77 NP B 127 43         +OTTER,KLEIN,+    (AACH+BERL+CERN+LOIC+WIEN)
PAWLICKI 77 PR D 15 3196        +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND  (ANL)I JP

ABRAMS   79  SLAC-PUB 2421      +ALAM,BLOCKER,BOYARSKI,+           (SLAC+LBL)
BECKER   79 NP B 151  46        +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN   79 NP B 157 250        +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC)  JP
GORLICH  79  CERN/EP 79-139     +NICZYPORUK,ROZANSKA+ (CRAC+MPIM+CERN+ZEEM)
MARTIN   79 NP B 158 520        +OZMUTLU                               (DURH)
POLYCHRO 79 PR D 19 1317        POLYCHRONAKOS,CASON,BISHOP+        (NDAM+ANL)
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F_1(1540)

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47  F1(1540,JPG=   ) I=1

JP = 2-,1+ FAVORED.
A NEW EXPERIMENT (CERRADA 77, MONTANET 77)
WITH 5 TIMES THE STATISTICS OF AGUILAR 69 DOES
NOT CONFIRM THE F1. OMITTED FROM TABLE.

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                        47  F1 MASS (MEV)

M        10(1490.0)   (20.0)          ADERHOLZ  69 HBC  +   8 PI+ P,KKBARPI.11/69
M       142 1540.0      5.0           AGUILAR   69 HBC     0.7PBARP,KKBARPI 11/69
M        25(1543.0)    (3.0)          DUBOC     71 HBC   0 1.1-1.2 PBAR P . 2/72
M   B    70(1557.)    (10.)           BAKKEN    75 HBC  +  19 PP,PN3PI       12/75
M   B    DUBIOUS BACKGROUND SUBTRACTION

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                        47  F1 WIDTH (MEV)

W        10  (85.0)   (39.0)          ADERHOLZ  69 HBC  +   8 PI+ P,KKBARPI 11/69
W       142   40.0     15.0           AGUILAR   69 HBC     0.7PBARP,KKBARPI 11/69
W        25  (16.0)   (10.0)          DUBOC     71 HBC   0 1.1-1.2 PBAR P    2/72
W   B    70  (40.)    (10.)           BAKKEN    75 HBC  +  19 PP,PN3PI       12/75
W   B    DUBIOUS BACKGROUND SUBTRACTION

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                        47  F1 PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      F1 INTO K KBAR PI                                134+ 497+ 497
P2      F1 INTO K*(892) KBAR                             892+ 497
P3      F1 INTO 3 PI                                     139+ 139+ 139

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                        REFERENCES FOR F1

ADERHOLZ 69 NP B 11 259         +BARTSCH,+         (AACH+BERL+CERN+CRAC+WARS)
AGUILAR  69 PL 29 B 379         +BARLOW,JACOBS,D-ANDLAU,ASTIER+ (CERN+CDEF)
AGUILAR  69 NP B 14 195         +BARLOW,JACOBS,D-ANDLAU,ASTIER+ (CERN+CDEF)

DUBOC    71 PL 34 B 343         +GOLDBERG,MAKOWSKI,TOUCHARD,+    (IPNP+LIVP)

CHAPMAN  72 NP B 42 1           +CHURCH,LYS,MURPHY,RING,VANDER VELDE (MICH)
DUBOC    72 NP B 46 429         +GOLDBERG,MAKOWSKI,DONALD,+      (LPNP+LIVP)

BAKKEN   75 NP B90 227          +JACOBSEN,OLSSON,SKJEVLING              (OSLO)G=-

CERRADA  77  PREPR.BUDAPEST C +DIAZ,FERRANDO,GARZON+(MADR+TATA+CERN+CDEF)
MONTANET 77  PRIVATE COMMUN.  L. MONTANET                              (CERN)

MINNAERT 78 NP B 132 88         +BILLY,+     (BORD+LPNP+LAUS+NEUC+LIVP+GLAS)  JP
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ρ′(1600)

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65  RHO PRIME(1600,JPG=1-+) I=1
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The ρ′(1600) was first seen in the $\pi^+\pi^+\pi^-\pi^-$ system, or its $\rho^0\pi^+\pi^-$ subsystem, in photoproduction (BINGHAM 72, DAVIER 73, SCHACHT 74, ALEXANDER 75, LEE 75, ATIYA 79, RICHARD 79) and in e^+e^- annihilation (BARBARINO 72, CONVERSI 74, CORDIER 79, COSME 79). The $\pi^+\pi^-$ system in the $\rho^0\pi^+\pi^-$ final state is apparently in an S wave, although no ε resonance at

Mesons

$\rho'(1600)$

Data Card Listings

For notation, see key at front of Listings.

sufficiently low mass exists to make this final state a quasi-two-body $\rho\varepsilon$ system. For this reason all $\rho\varepsilon$ analyses have difficulties and all mass fits are strongly parametrization dependent (SMADJA 72, BUDNEV 77, CORDIER 79). Moreover, other mechanisms exist that can simulate a resonance peak in e^+e^- annihilations to 4π (HIRSCHFELD 74) and in photoproduction (SCHACHT 74).

Evidence for a 2π decay mode has been looked for in phase-shift analyses of the $\pi^-p \to \pi^+\pi^-n$ reaction, as well as in photoproduction and e^+e^- annihilations. The decay $\rho' \to \pi^+\pi^-$ has been reported in photoproduction (ATIYA 79, RICHARD 79) with a branching ratio of $16 \pm 5\%$ (RICHARD 79). This information can now be used to distinguish between the various phase-shift solutions.

As noted in the mini-review on S-wave $\pi\pi$ interactions, the solutions denoted β' and β of MARTIN 77 fit the data of BECKER 79 best, with a slight preference for solution β' in the ρ' region, 1.5 to 1.7 GeV. Both solutions require a ρ' at 1575 MeV. However, solution β has a branching ratio to 2π of 30%, while β' has a branching ratio of only 15%. Thus the photoproduction data also select β'.

The unique solution of FROGGATT 77 and the solution B of CORDEN 79 are similar to solution β (having, however, problems with the unitarity of the S wave).

Further support for the $\rho'(1600)$ comes from an analysis of the pion form factor (GENSINI 78). No $\rho'(1250)$ is required in $e^+e^- \to \pi^+\pi^-$ when the analysis is extended well outside the $\rho'(1600)$ region. The $\rho'(1250)$ resonance, claimed mainly by vector dominance arguments to explain the nucleon form factors, is also not found in any of the phase-shift solutions. The $J^P = 1^-$ partial wave of the $\omega\pi$ system is expected to contribute to the pion form factor (ROOS 75, COSTA1 77); it is indeed strong in the 1250 MeV region, but does not exhibit a resonance behavior (CHUNG 73,75, CHALOUPKA 74, BUDNEV 77, GESSAROLI 77).

The $\rho'(1600)$ is most explicitly seen in e^+e^- annihilations into three or more hadrons (BACCI 79). Some support for a $\rho'(1600)$ decay into e^+e^- has been claimed in $\bar{p}p$ annihilation (BASSOMPIERRE 76).

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                        65  RHO PRIME MASS (MEV)

M       400 1430.     50.                    BINGHAM   72 HBC   0 9.3 GAM P,P 4PI  12/72
M   H      (1590.)   (20.)                   HYAMS     73 ASPK  0 17 PI-P,N PI+PI-  1/74
M           1550.     60.                    CONVERSI  74 OSPK  0 E+ E- TO 4PI     12/75
M       160 1550.     50.                    SCHACHT   74 STRC  0 5.5-9 G P,P 4PI  12/75
M       340 1450.    100.                    SCHACHT   74 STRC  0 9-18 G P,P 4PI   12/75
M        65 1570.     60.                    ALEXANDER 75 HBC   0 7.5 GAM P,P 4PI  12/75
M  P        1610.     30.                    FROGGATT  77 RVUE  0 17 PI-P,PI+PI-N  12/77
M           1540.     30.                    LAPLANCHE 77 OSPK  0 E+E- TO 4PI,6PI   1/78
M  P       (1575.)                           MARTIN    78 RVUE  0 17 PI-P,PI+PI-N  12/77
M    R      1600.0    10.0                   ATIYA     79 SPEC    50 GAM C,2PI     12/79*
M           1558.0    24.0      22.0         BECKER    79 ASPK  0 17 PI- P POLARIZ 12/79*
M    N      1533.0    21.0                   COSME     79 OSPK  0 E+ E-,4PI        12/79*
M          (1600.0)  APPROX.                 RICHARD   79 OMEG    20-70 GAM P,2PI  12/79*
M    M      1650.0    20.0                   SPINETTI  79 RVUE    E+ E-            12/79*
M            . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

M   H    INCLUDED IN BECKER 79 ANALYSIS
W    M   WITH ONLY ONE BREIT WIGNER FIT.
M    N   WITH TWO BREIT WIGNER FIT
M  P     FROM PHASE SHIFT ANALYSIS OF HYAMS 73 DATA
M    R   AN ADDITIONAL 40 MEV UNCERTAINTY IN BOTH THE MASS AND WIDTH
M    R   IS PRESENT DUE TO THE CHOICE OF THE BACKGROUND SHAPE.

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                        65  RHO PRIME WIDTH (MEV)

W       400  650.    100.                    BINGHAM   72 HBC   0 9.3 GAM P,P 4PI  12/72
W   H       (180.)   (50.)                   HYAMS     73 ASPK  0 17 PI-P,N PI+PI- 12/75
W            360.    100.                    CONVERSI  74 OSPK  0 E+ E- TO 4PI     12/75
W  E    160  400.    120.                    SCHACHT   74 STRC  0 5.5-9 G P,P 4PI  12/75
W  E    340  850.    200.                    SCHACHT   74 STRC  0 9-18 G P,P 4PI   12/75
W  E     65  340.    160.                    ALEXANDER 75 HBC   0 7.5 GAM P,P 4PI  12/75
W  P         300.    100.                    FROGGATT  77 RVUE  0 17 PI-P,PI+PI-N  12/77
W            220.     70.                    LAPLANCHE 77 OSPK  0 E+E- TO 4PI,6PI   1/78
W  P        (340.)                           MARTIN    78 RVUE  0 17 PI-P,PI+PI-N  12/77
W    R       283.0    14.0                   ATIYA     79 SPEC    50 GAM C,2PI     12/79*
W            175.0    98.0      53.0         BECKER    79 ASPK  0 17 PI- P POLARIZ 12/79*
W    N       202.0    70.0                   COSME     79 OSPK  0 E+ E-,4PI        12/79*
W            230.0    80.0                   RICHARD   79 OMEG    20-70 GAM P,2PI  12/79*
W    M       710.0   160.0                   SPINETTI  79 RVUE    E+ E-            12/79*
W            . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

W  E     WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NCTE
W   H    INCLUDED IN BECKER 79 ANALYSIS
W    M   WITH CNLY ONE BREIT WIGNER FIT.
W    N   WITH TWO BREIT WIGNER FIT
W  P     FROM PHASE SHIFT ANALYSIS OF HYAMS 73 DATA
W    R   AN ADDITIONAL 40 MEV UNCERTAINTY IN BOTH THE MASS AND WIDTH
W    R   IS PRESENT DUE TO THE CHOICE OF THE BACKGROUND SHAPE.

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                        65  RHO PRIME PARTIAL DECAY MODES

                                                                 DECAY MASSES
P1      RHO PRIME INTO RHO PI PI                                139+ 139+ 776
P2      NEUTRAL RHO PRIME INTO ALL 4 CHARGED PI MODES           139+ 139+ 139+ 139
P3      RHO PRIME INTO RHO RHO                                  776+ 776
P4      RHO PRIME INTO PI PI                                    139+ 139
P5      RHO PRIME INTO KBAR K                                   493+ 493
P6      RHO PRIME INTO PI OMEGA                                 139+ 782
P7      RHO PRIME INTO PI+ PI- PIO PIO                          139+ 139+ 134+ 134

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                        65  RHO PRIME BRANCHING RATIOS

R1      RHO PRIME INTO (RHO PI+ PI-)/(4 PI, ALL CHARGED) (P1)/(P2)
R1 S       DCMINANT                    BARBARINO 72 OSPK    E+E- TC 4 PI       1/73
R1 S          (.80)                    BINGHAM   72  HBC    9.3 GAM P,P 4PI    1/73
R1      500    0.7       0.1           SCHACHT   74 STRC    5.5-18 G P,P 4PI 12/75
R1 S     THE PI PI SYSTEM IS IN S WAVE                                         1/73

R2      RHO PRIME INTO (RHO 0 RHO 0)/(RHO 0 PI+ PI-)        (P3)/(P1)
R2           NONE    (FORBIDDEN BY I=1)BINGHAM   72  HBC    9.3 GAM P,P 4PI    1/73

R3      RHO PRIME INTO (PI+ PI-)/(4 PI, ALL CHARGED)        (P4)/(P2)
R3           (.2) OR LESS  2 SIGMA  BINGHAM   72  HBC   0 9.3 GAM P,P 2PI    1/73
R3          (0.14) OR LESS  ESTIMATE DAVIER    73 STRC  0 6-18 G P,P 4PI     1/74
R3            0.16      0.05           RICHARD   79 OMEG    20-70 GAM P,2PI  12/79*

R4      RHO PRIME INTO (KBAR K)/(4 PI, ALL CHARGED)         (P5)/(P2)
R4           (.04) OR LESS  CL=0.95  BINGHAM   72  HBC   0 9.3 GAM P        . 1/73

R5      RHO PRIME INTO (PI+PI-)/TOTAL                       (P4)
R5  E       (0.15) OR LESS             EISENBERG 73 HBC     5 PI+ P,DEL++2PI   1/74
R5  H       (0.25)    (0.05)           HYAMS     73 ASPK    17 PI-P,N PI+PI-   1/74
R5            0.20      0.05           MONTANET  73 HBC     PBAR P AT REST    12/77
R5 C        (0.20) OR LESS             COSTA 2   77 RVUE    E+E-,2 PI + 4 PI 12/77
R5  P        (.30)     (.05)           FROGGATT  77 RVUE    17 PI-P,PI+PI-N  12/77
R5 P        (0.15)TO 0.30              MARTIN    78 RVUE    17 PI-P,PI+PI-N  12/77
R5            0.287     0.043     0.042 BECKER    79 ASPK  0 17 PI- P PCLARIZ 12/79*
R5 C     ESTIMATE USING UNITARITY,TIME REVERSAL INVARIANCE,BREIT WIGNER
R5  E    ESTIMATED USING OPE MODEL.
R5  H    INCLUDED IN BECKER 79 ANALYSIS
R5 P     FROM PHASE SHIFT ANALYSIS OF HYAMS 73 DATA
R5            . . . . . . . . . .
R5   AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

R6      RHO PRIME INTO (PI+ PI- PIO PIO)/(4PI, ALL CHARGED)
R6                                                          (P7)/(P2)
R6           (1.)    OR LESS  ESTIMATE DAVIER    73 STRC    6-18 G P,P 4PI     1/74

R7      RHO PRIME INTO (PI+ PI- + NEUTRALS)/(4PI,ALL CHARGED)
R7                                                          (P7+....)/(P2)
R7  U        (2.6)     (0.4)           BALLAM    74 HBC     9.3 GAMMA P       12/75
R7  U    UPPER LIMIT. BACKGROUND NOT SUBTRACTED

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REFERENCES FOR RHO PRIME


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ALVENSLE 71 PRL 26 273        ALVENSLEBEN,BECKER,BERTRAM,CHEN,+(DESY+MIT) G
BRAUN    71 NP B30 213        +FRIDMAN, GERBER, GIVERNAUD,+  (STRASBOURB) G
BULOS    71 PRL 26 149        +BUSZA,KEHOE,BENISTON,+  (SLAC+UMD+IBM+LBL) G

BACCI    72 PL 38B 551        +PENSO,SALVINI,STELLA,BALDINI-CE(ROMA+FRAS) JPC
BARBARIN 72 LNC 3 689         BARBARINO,CERADINI,+   (FRAS+RCMA+PADO+UMD)IGJP
BARTOLI  72 PR D 6 2374       +FELICETTI,OGREN,+          (FRAS+ROMA+NAPL)IGJP
BINGHAM  72 PL 41B 635        +RABIN,ROSENFELD,SMADJA,YOST+(LBL,UCB,SLAC)IGJP
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Data Card Listings

For notation, see key at front of Listings.

Mesons

$\rho'(1600)$, $A_3(1660)$


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BRAMON    72 LNC 3 693            +GRECO (THEORETICAL PAPER)       (FRASCATI)
DIEBOLD   72  BATAV.CONF.         R.DIEBOLD  RAPPORTEUR TALK            (ANL)
EISENBER  72 PR D 5 15            EISENBERG,BALLAM,DAGAN,+   (REHO+SLAC+TELA)
LAYSSAC   72 NC 10A 407           J.LAYSSAC,F.M.RENARD                 (MONP)
SMADJA    72 PHIL.CONF.PROC349    +BINGHAM,FRETTER,BALLAM,CHADWICK+(LBL+SLAC)

CERADINI  73 PL 43 B 341          +CONVERSI,EKSTRAND,GRILLI,+(ROMA+FRAS+PADO)IGJP
CHUNG     73 PL 47 B 526          +PROTOPOPESCU,LYNCH,FLATTE+    (BNL+LBL+USC)
DAVIER    73 NP B 58 31           +DERADO,FRIES,LIU,MOZLEY,ODIAN,PARK,+(SLAC)
EISENBER  73 PL 43 B 149          EISENBERG,KARSHON,MIKENBERG,PITLUCK,+(REHO)
HYAMS     73 NP B 64 134          +JONES,WEILHAMMER,BLUM,DIETL,+  (CERN+MPIM)
KREUZER   73 PR D 8 1431          H.J.KREUZER,A.N.KAMAL     (UNIV. OF ALBERTA)
OCHS      73 THESIS               THESIS                               (MPIM)
MONTANET  73 ERICE SCHOOL 518     L.MONTANET                           (CERN)
PARK      73 NP B 58 45           J.C.H.PARK                           (MPIM)  JP

BALLAM    74 NP B76 375           +CHADWICK,BINGHAM,FRETTER+  (SLAC+LBL+MPIM)
BERNABEI  74 LNC 11 261           +D.ANGELO,SPILLANTINI,VALENTE   (ROMA+FRAS)
CHALOUPK  74 PL 51 B 407          CHALOUPKA,FERRANDO,LOSTY,MONTANET    (CERN)
CONVERSI  74 PL 52B 493           +PAOLUZI,CERADINI,GRILLI+       (ROMA+FRAS)
ESTABROO  74 NP B79 301           P.ESTABROOKS,A.D.MARTIN              (DURH)
FERBEL    74 PR D9 824            T.FERBEL AND P.SLATTERY              (RCCH)
GRAYER    74 NP B 75 189          G.GRAYER,HYAMS,BLUM,DIETL,+     (CERN+MPIM)
HIRSHFEL  74 NP B74 211           A.C.HIRSHFELD,G.KRAMER               (HAMB)
SCHACHT   74 NP B81 205           +DERADO,FRIES,PARK,YOUNT             (MPIM)

ALEXANDE  75 PL 57B 487           ALEXANDER,BENARY,GANDSMAN,LISSAUER+  (TELA)
ALLES     75 NC 30A 136           ALLES-BORELLI,BERNARDINI+  (CERN+BGNA+FRAS)
CHUNG     75 PR D 11 2436         +PROTOPOPESCU,LYNCH,FLATTE+    (BNL+LBL+USC)
ESTABROO  75 NP B95 322           P.ESTABROOKS,A.D.MARTIN              (DURH)
FROGGATT  75 NP B91 454           C.D.FROGGATT,J.L.PETERSEN       (GLAS+NORD)
HYAMS     75 NP B10C 205          +JONES,WEILHAMMER,BLUM,DIETL+   (CERN+MPIM)
LANG      75 PL 58B 450           C.B.LANG,I.S.STEFANESCU              (KARL)
LANGACKE  75 PR D 13 697          P.LANGACKER,G.SEGRE                  (PENN)
LEE       75 STANFORD CONF.213    WONYONG LEE                          (COLU)
ROOS      75 NP B 97 165          M.ROOS                               (HELS)

BASSOMPI  76 PL 65 B 397          BASSOMPIERRE,BINDER,+      (MULH+STRB+TCRI)
COMMON    76 NP B 103 109         A.K.COMMON                           (KENT)  JP
JOHNSON   76 PL 63 B 95           +MARTIN,PENNINGTON              (DURH+CERN)  JP

BUDNEV    77 PL 70 B 365          N.M.BUDNEV,V.M.BUDNEV,V.V.SEREBRYAKOV(NOVO)
COSTA 1   77 PL 67 B 213          COSTA DE BEAUREGARD,PHAM,PIRE,TRUONG (EPOL)
COSTA 2   77 PL 71 B 345          COSTA DE BEAUREGARD,PIRE,T.N.TRUONG  (EPOL)
FROGGATT  77 NP B 129 89          C.D.FROGGATT,J.L.PETERSEN       (GLAS+BCHR)
GESSAROL  77 NP 8 126 382         GESSAROLI+   (BGNA+FIRZ+GENO+MILA+OXF+PAVI)
LAPLANCH  77 HAMBURG CONF.        F. LAPLANCHE                         (ORSA)

GENSINI   78 PR D 17 1368         PAOLO M GENSINI                      (SLAC)
MARTIN    78 ANP  114 1           A.D.MARTIN,M.R.PENNINGTON            (CERN)

ATIYA     79 PRL 43 1691          +HOLMES,KNAPP,LEE,SETO,+    (COLU+ILL+FNAL)
BACCI     79 PL B 86 234          +DE ZORZI,PENSO,STELLA,+   (ROMA+BGNA+FRAS)
BECKER    79 NP B 151  46         +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN    79 NP B 157 250         +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LCWC)  JP
CORDIER   79 PL 81 B 389          +DELCOURT,ESCHSTRUTH,FULDA+          (LALO)
COSME     79 NP B 152 215         +DUDELZAK,GRELAUD,JEAN-MARIE,JULLIAN+ (IPN)
RICHARD   79  LAL-79/35           F. RICHARD                           (LALO)
SPINETTI  79  PREP. LFN-79/65     M. SPINETTI                          (FRAS)
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$A_3(1660)$

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34  A3(1660,JPG=2--) I = 1
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Evidence for the existence of the A_3 meson was previously confused due to its appearance near $f\pi$ threshold in the diffractive-like process $\pi N \to \pi\pi\pi N$, much like the A_1 meson. While everybody agreed that there was a $\approx$300 MeV wide $f\pi$ enhancement in the $J^P LM = 2^- S0$ partial wave at about 1650 MeV, some claimed non-resonant status (ANTIPOV1 73, ASCOLI1 73, BALTAY 77, GHIDINI 77), while others saw evidence for a resonance in the phase variation with respect to other partial waves (OTTER 74, THOMPSON 74).

In the non-diffractive charge-exchange reaction $\pi^+ p \to \pi^+\pi^-\pi^0\Delta^{++}$ (WAGNER 75, BALTAY 77, CAUTIS 77) and in the hypercharge exchange reaction $K^- p \to \pi^+\pi^-\pi^0\Lambda$ at 4.2 GeV/c (CERRADA 77), there is no evidence for A_3 production.

Definitive proof for the resonant nature of the A_3 has been given by PERNEGR 78 using 60,000 3π events, diffractively produced by incident π^- on nuclei, and by DAUM 80 in an analysis of nearly 600,000 events of the reaction $\pi^- p \to \pi^-\pi^-\pi^+ p$. A partial-wave analysis shows the 3π system to be resonant in the S-wave $f\pi$ system as well as in the P-wave $\rho^0\pi$ system and in the D-wave $\varepsilon\pi$ system.

Beyond the A_3 meson, the $J^P = 2^-$ phase seems to continue to increase, indicating the possible existence of a second resonance in this wave at $M = (2000 \pm 100)$ MeV, $\Gamma \approx 400$ MeV (DAUM 80).

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                    34  A3 MASS (MEV)

M        30(1600.0)                       FORINO    65 DBC    04.5 PI+ D      10/66
M        20(1630.0)  (30.0)               VETLITSKY 66 HBC  -  4.7 PI- P      12/75
M          (1630.)   (10.)                BALTAY    68 HBC  +  7, 8.5 PI+ P   12/75
M          (1660.0)  (16.0)               BARTSCH   68 HBC  +  8. PI+ P,3PI P 12/75
M          (1610.)   (19.)                LAMSA     68 HBC  -  8.0 PI-P, PI-F 12/75
M       297(1673.0)  (40.0)               ARMENISE  69 DBC  +  5.1 PI+D,3PI++- 12/75
M          (1680.)   (20.0)               CASO      69 HBC  -  11 PI- P        5/70
M           1660.0    20.0                CASO      69 HBC  -  11 PI-P, PI-F  12/75
M           1645.0    10.0                CRENNELL  70 HBC  -  6. PI- P,F PI  12/75
M   M      (1633.0)  (12.0)               MIYASHITA 70 HBC  -  6.7 PI-P,PI-F   1/71
M    F     (1672.0)                       BEKETOV   71 HBC  -  4.45 PI- P     11/71
M          (1600.)   (50.)                PALER     71 DBC  + 13.PI+ D,D(3PI)+ 12/75
M       260 1660.     25.                 CASC      72 HBC  + 11.7 PI+ P      12/75
M    F      1658.      8.                 HARRISON  72 HBC  - 13.,20. PI- P   12/72
M    P      1650.     30.                 ANTIPOV1  73 CNTR - 25.,40. PI- P   12/75
M    P      1660.     10.                 ASCOLI 1  73 HBC  - 5.-25.PI- P,P A3 12/75
M  P E     (1600.)   (10.)                THOMPSON  74 HBC  + 13. PI+ P,P A3+ 12/75
M   B   575(1640.)   (10.)                KALELKAR  75 HBC  + 15 PI+P,P PI+F  12/75
M    P  2M 1662.0     10.0                BALTAY    77 HBC  0 15 PI+ P,P 3PI  12/77
M    P  2M(1680.0)   (8.0)                GHIDINI   77 OMEG - 12 PI-P,P 3PI   12/77
M    R     (1650.0)                       PERNEGR   78 CNTR - 9+13+15,PI- NUC.  4/78*
M  P D      1671.0     2.0                DAUM      80 SPEC - 63-94 PI- P, 3PI 12/79*
M           . . . . . . . . . .
M   AVG     1668.6     2.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
M   STUDENT1668.7      2.3     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M   B   SAME EXPERIMENT AS BALTAY 77
M    D     CLEAR PHASE ROTATION SEEN IN  (2-S),(2-P),(2-D) WAVES.
M    E  EVIDENCE FOR A ROTATION OF THE PHASE CLAIMED.
M   F   FIT ASSUMES AN ADDITIONAL PEAK AT 1830 MEV.
M   M   BACKGROUND SUBTRACTION DIFFICULT.
M  P    FROM A FIT TO JP=2-S (F PI) PARTIAL WAVE
M    R  CLEAR PHASE ROTATION SEEN IN (2-S) AND (2-P) WAVES

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                    34  A3 WIDTH (MEV)

W        20 (100.)                        VETLITSKY 66 HBC  -  4.7 PI-P        6/66
W   M        (70.)   (40.)                BALTAY    68 HBC  +  7, 8.5 PI+ P    6/68
W           (115.0)  (45.0)               BARTSCH   68 HBC  +  8. PI+ P,3PI P 12/75
W   M       (100.)   (50.)      (30.)     LAMSA     68 HBC  -  8.0 PI-P  PI-F 11/67
W      297  240.0     50.0                ARMENISE  69 DBC  +  5.1 PI+D,3PI++-  5/70
W           (130.)                        CASO      69 HBC  -  11 PI- P        6/68
W           (150.0)                       CASO      69 HBC  - 11.0 PI-P,PI- F  6/68
W            130.0    30.0                CRENNELL  70 HBC  -  6. PI- P,F PI  . 5/70
W   M        (37.0)  (24.0)               MIYASHITA 70 HBC  -  6.7 PI-P,PI-F   1/71
W   F       (128.0)                       BEKETOV   71 HBC  -  4.45 PI- P     11/71
W           (220.)   (80.)                PALER     71 DBC  + 13.PI+ D,D(3PI)+.12/75
W  P         200. TO 400.                 CASO      72 HBC  + 11.7 PI+ P       1/72
W      260  190.     100.                 CASO      72 HBC  + 11.7 PI+ P      12/75
W   F        (53.)   (20.)      (16.)     HARRISON  72 HBC  - 13.,20. PI- P   12/72
W  P         300.     50.                 ANTIPOV1  73 CNTR - 25.,40. PI- P   12/75
W  P         270.     60.                 ASCOLI 1  73 HBC  - 5.-25.PI- P,P A3 12/75
W  P E      (310.)   (40.)                THOMPSON  74 HBC  + 13. PI+ P,P A3+ 12/75
W   B  575 (240.)    (30.)                KALELKAR  75 HBC  + 15 PI+P,P PI+F  12/75
W  P  2000  285.0     60.0                BALTAY    77 HBC  0 15 PI+ P,P 3PI  12/77
W  P  2000 (220.0)   (30.0)               GHIDINI   77 OMEG - 12 PI-P,P 3PI   12/77
W    R      (400.0)                       PERNEGR   78 CNTR - 9+13+15,PI- NUC.  4/78*
W  P D       207.0    10.0                DAUM      80 SPEC - 63-94 PI- P, 3PI 12/79*
W            . . . . . . . . . .
W   AVG      207.2    14.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
W   STUDENT 208.7     10.2     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W   B   SAME EXPERIMENT AS BALTAY 77
W    D     CLEAR PHASE ROTATION SEEN IN  (2-S),(2-P),(2-D) WAVES.
W    E  EVIDENCE FOR A ROTATION OF THE PHASE CLAIMED.
W   F   FIT ASSUMES AN ADDITIONAL PEAK AT 1830 MEV.
W   M   BACKGROUND SUBTRACTION DIFFICULT.
W  P    FROM A FIT TO JP=2- F PI PARTIAL WAVE
W    R  CLEAR PHASE ROTATION SEEN IN (2-S) AND (2-P) WAVES

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                    34  A3 PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      A3 INTO 3 PI                                     134+ 134+ 134
P2      A3 INTC RHO PI                                   134+ 776
P3      A3 INTO ETA PI                                   134+ 548
P4      A3 INTC 5 PI                                     139+ 139+ 139+ 139+
P5      A3 INTO K K*(892)                                497+ 892
P6      A3 INTO K KBAR PI                                497+ 497+ 134
P7      A3 INTO K KBAR                                   497+ 497
P8      A3 INTO F PI                                    1273+ 134
P9      A3 INTO OMEGA PI PI                              782+ 134+ 134
P10     A3 INTO 3 PI                                     139+ 139+ 139

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                    34  A3 BRANCHING RATIOS

R2      A3+- INTO (PI+- RHOO)/(ALL PI+- PI+ PI-)          (P2C)/(P1C)
R2            (0.3)  OR LESS          BARTSCH   68 HBC  +  8. PI+ P,3PI P   8/69
R2            (0.4)  OR LESS          FERBEL    68 RVUE +-                . 9/68
R2             (.18) OR LESS  CL=.95  PALER     71 DBC  + 13.P++ D,D(3P+)+ 11/71
R2             0.32      0.06         DAUM      80 SPEC   63-90 PI- P,3PI  12/79*

R3      A3+- INTO (PI+- F)/(ALL PI+- PI+ PI-)             (P8)/(P1C)
R3                  (WITH F INTO PI+ PI-)
R3             INDICATION SEEN        LUBATTI   66 HLBC    16 PI-          11/66
R3            (0.59)FOR JP=2-         BARTSCH   68 HBC  +  8. PI+ P,3PI P   8/69
R3            (0.51)FOR JP=1+         BARTSCH   68 HBC  +  8. PI+ P,3PI P   8/69
R3            (0.20)FOR JP=0-         BARTSCH   68 HBC  +  8. PI+ P,3PI P   8/69
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Mesons

$A_3(1660)$, $\omega(1670)$, g(1700)

Data Card Listings

For notation, see key at front of Listings.

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R3          (0.35)    (0.20)           BALTAY     68 HBC  +  7-8.5 PI+P       . 5/68
R3           CONSISTENT WITH 1.0       CASO       68 HBC   -  11 PI- P          6/68
R3          (0.76)    (0.24)    (0.34) ARMENISE   69 DBC  +   5.1 PI+D,3PI++-  5/70
R3           CONSISTENT WITH 1.0       CRENNELL   70 HBC   -  6. PI- P,F PI   . 5/70
R3           (.85) OR MORE  CL=.95     PALER      71 DBC  +  13.P++ D,D(3P+)+ 11/71
R3           CONSISTENT WITH 1.0       LICHTMAN   74 HBC  +- 18.5 PI+-P,P 3PI 12/75
R3           CONSISTENT WITH 1.0       KALELKAR   75 HBC  +  15 PI+P,P 3PI     12/75
R3           0.57         0.03         DAUM       80 SPEC  - 63-90 PI- P,3PI   12/79*

R5     A3+- INTO (PI+- ETA)/(ALL PI+- PI+ PI-)           (P3)/(P1C)
R5                   (ALL ETA DECAYS)
R5          (0.09) OR LESS             BALTAY     68 HBC  +  7-8.5 PI+P         5/68
R5          (0.10) OR LESS             CRENNELL   70 HBC   -  6. PI- P,F PI     5/70

R6     A3+- INTO (PI+- 2PI+ 2PI-)/(ALL PI+- PI+ PI-)     (P4C)/(P1C)
R6          (0.1)  OR LESS             BALTAY     68 HBC  +  7,8.5 PI+ P        6/68
R6          (0.10) OR LESS             CRENNELL   70 HBC   -  6. P+- P,F P+     5/70

R8     A3+- INTO (RHO PI)/(F PI)                          (P2)/(P8)
R8          (0.03)    (0.37)    (0.03) CASO       69 HBC   -  11 PI- P         12/75

R9     A3+- INTO (PI+- PI+ PI-)/(F PI)                    (P1C-P8)/(P8)
R9          (0.06)    (0.47)    (0.06) CASO       69 HBC   -  11 PI- P         12/75
R9        POSSIBLY SEEN                HARRISON   72 HBC  -  13.,20. PI- P     12/72

R10    A3+- INTO (UNCORREL.PI+- PI+ PI-)/(ALL PI+- PI+ PI-)
R10 M        (.05) OR LESS  CL=.95     PALER      71 DBC  +  13. PI+D,D(3PI)+ 11/71
R10 M   MODEL DEPENDENT FIT

R11    A3+-  INTO  (PI+- EPSILON)/(ALL PI+- PI+ PI-)     (P11)/(P16)
R11          0.11       0.05           DAUM       80 SPEC  - 63-90 PI- P, 3PI 12/79*

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REFERENCES FOR A3


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FORINO   65 PL 19 68              +GESSAROLI+      (BGNA+BARI+FIRZ+ORSA+SACL)
FOCACCI  66 PRL  17  890          CERN MISSING MASS SPECTROMETER GROUP (CERN)
LEVRAT   66 PL   22  714          CERN MISSING MASS SPECTROMETER GROUP (CERN)
LUBATTI  66 THESIS BERKELEY       H.J.LUBATTI                         (LRL)1-2-
VETLITSK 66 PL   21  579          VETLITSKY,GUSZAVIN,KLIGER,ZOLGANOV+  (ITEP)
DANYSZ   67 NC 51 A 801           DANYSZ+FRENCH+SIMAK                  (CERN)
DUBAL    67 NP B3 435             CERN MISSING MASS SPECTROMETER GROUP (CERN)
   ALSO  68 THESIS 1456           L.DUBAL                            (GENEVE)

BALTAY   68 PRL 20 887            +KUNG+YEH+FERBEL+     (COLU+ROCH+RUTG+YALE)I=1
BARTSCH  68 NP B 7 345            +KEPPEL,KRAUS,+             (AACH+BERL+CERN) JP
CASO     68 NC 54 A 983           +CONTE+CORDS+DIAZ+  (GENOVA+HAMB+MILA+SACL)
FERBEL   68 PHILA.CONF.335        T.FERBEL                         (ROCHESTER)
IOFFREDO 68 PRL 21 1212           +BRANDENBURG,BRENNER,EISENSTEIN+  (HARVARD)
LAMSA    68 PR 166 1395           +CASON+BISWAS+DERADO+GROVES+     (NOTREDAME)

ARMENISE 69 LNC 2 501             +GHIDINI,FORINO,CARTACCI+  (BARI+BGNA+FIRZ)
BARNES   69 PRL 23 142            +CHUNG,EISNER,FLAMINIO,+              (BNL)
CASO     69 LNC 2 437             +CONTE,TOMASINI,CANTORE+   (GENO+MILA+SACL)
   ALSO  68 CASO

BRANDENB 70 NP B16 369            +BRENNER,IOFFREDO,JOHNSON,KIM+      (HARVARD)
CRENNELL 70 PRL 24 781            +KARSHON,LAI,SCARR,SIMS               (BNL)
CHIEN    70 PHILAD.CONF.P.275 C.Y.CHIEN, REVIEW               (JOHNS HOPKINS)
MIYASHIT 70 PR D 1 771            MIYASHITA,VON KROGH,KOPELMAN,LIBBY   (COLO)

BEKETOV  71 SJNP 4 765            +SOMBKOWSKY,KONOWALOV,KRUTSCHININ,+  (ITEP)   JP
PALER    71 PRL 26 1675           +BADEWITZ,BARTON,MILLER,PALFREY,TEBES(PURD)

ALEXANDE 72 NP B 45 29            ALEXANDER,BAR-NIR,BENARY,DAGAN,+      (TELA)
ARMENISE 72 LNC 4 201             +FORINO,CARTACCI,+           (BARI+BGNA+FIRZ)
CASO     72 NP B 36 349           +MADDOCK,BASSLER+(DURH+GENO+DESY+MILA+SACL)
HARRISON 72 PRL 28 775            +HEYDA,JOHNSON,KIM,LAW,MUELLER,+      (HARV)
SALZBERG 72 NP B 41 397           +HARRISON,HEYDA,JOHNSON,KIM,LAW,+     (HARV)

ANTIPOV1 73 NP B 63 153           +ASCOLI,BUSNELLO,FOCACCI,+       (CERN+SERP)  JP
ANTIPOV2 73 NP B 63 141           +ASCOLI,BUSNELLO,FOCACCI,+       (CERN+SERP)  JP
ASCOLI 1 73 PR D 7 669            INTERNAT. COLLABORATION               (ILL+)  JP
ASCOLI 2 73 PR D 8 3894           +JONES,WEINSTEIN,WYLD                 (ILL)   JP

ASCOLI   74 PR D9 1963            +CUTLER,JONES,KRUSE,ROBERTS,WEINSTEIN+(ILL)
LICHTMAN 74 NP B81 31             +BISWAS,CASON,KENNEY,MCGAHAN,+        (NDAM)
OTTER    74 NP B80 1              +RUDOLPH+         (AACH+BERL+BONN+CERN+HEID)  JP
TABAK    74 BOSTON CONF.          +RONAT,ROSENFELD,LASINSKI+       (LBL+SLAC)   JP
THOMPSON 74 PRL 32 331            +BADEWITZ,GAIDOS,MCILWAIN,PALER,+    (PURD)   JP
    ALSO 74 NP B69 381            THOMPSON,BADEWITZ,GAIDOS,MCILWAIN+   (PURD)   JP

BEKETOV  75 SJNP 20 379           +ZOMBKOVSKII,KAIDALON,KONOVALOV+     (ITEP)
EMMS     75 PL 60 B 109           +JONES,KINSON,BELL,DALE+   (BIRM+DURH+RHEL)   JP
HORNE    75 PR D11 996            +S.HAGOPIAN,V.HAGOPIAN,BENSINGER+(FSU+BRAN)
KALELKAR 75 THESIS(NEVIS 207) M.S.KALELKAR                             (COLU)
WAGNER   75 PL 58B 201            +TABAK,CHEW                            (LBL)  JP

BALTAY   77 PRL 39 591            +CAUTIS,KALELKAR                  (COLUMBIA)  JP
CAUTIS   77  THESIS NEVIS 221 C.V.CAUTIS                            (COLUMBIA)  JP
CERRADA  77 NP B 126 241          +BLOCKZIJL,HEINEN,+     (AMST+CERN+NIJM+OXF)  JP
GHIDINI  77  PREPRINT             +            (BARI+BONN+CERN+DARE+LIVP+MILA)  JP

BALTAY   78 PR D 17 52            +CAUTIS,COHEN,CSORNA,KALELKAR+  (COLU+BING)
CORDEN   78 NP B 136 77           DOWELL,GARVEY,JOBES+  (BIRM+RHEL+TELA+LOWC)   JP
PERNEGR  78 NP B 134 436          +AEBISCHER+              (ETH+CERN+LOIC+MILA)
ROBERTS  78 PR D 18 59            +KRUSE,EDELSTEIN+        (ILL+CARN+NWES+ROCH)

DAUM     80 PL 89 B 285           +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)   JP
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$\omega(1670)$

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45   OMEGA(1670,JPG=3--) I=0.

THIS RESONANCE OVERLAPS IN ITS 3PI MODE WITH THE A3,
BUT IN SOME EXPERIMENTS ONE CAN ESTABLISH THE DECAY
MODE RHOO PIO, THUS I=0. WAGNER 75 FIND JP=3- UNIQUELY.
CERRADA 77 SEE CLEAR PHASE ROTATION RESPECT TO FOUR
DIFFERENT REFERENCE WAVES. CONFIRMED BY CAUTIS 77.
THE DECAYS INTO 5PI AND OMEGA PI+ PI- NEED FURTHER
CONFIRMATION (SEE ALSO X(1690)).

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                  45   OMEGA(1670) MASS (MEV)

M           1636.      20.             ARMENISE   68 DBC    5.1 PI+N,P(3PI)0  9/68
M           1670.      20.             KENYON     69 DBC    8.  PI+N,P(3PI)0  8/69
M       200 1679.      17.             MATTHEWS   71 DBC    7.0 PI+N,P(3PI)0. 1/71
M       500 1678.      14.             DIAZ       74 DBC    6.  PI+N,P(3PI)0  1/74
M     Q 200 1660.      13.             DIAZ       74 DBC    6.  PI+N,P(5PI)0  1/74
M  P    600 1669.      11.             WAGNER     75 HBC    7. PI+P,DEL++3PI 11/75
M     E 110(1700.0)  APPROX.           CERRADA    77 HBC    4.2 K-P,LAM 3PI  12/77
M  P E 430 1673.0      12.0            BALTAY     78 HBC    15 PI+P,DEL 3PI   4/78*
M          1650.0      12.0            CORDEN     78 OMEG   8-12 PI- P,N 3PI 12/77
M       60 1685.0      20.0            BAUBILLIE 79 HBC     8.2K- P,BACKWARD 12/79*
M           . . . . . . . . . . .
M    AVG     1666.4     4.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    STUDENT1666.8      5.4      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M     E   PHASE ROTATION SEEN FOR JP 3- (RHO PI) WAVE.
M  P      FROM A FIT TO I=0, JP=3- RHO PI PARTIAL WAVE
M     Q   FROM (OMEGA PI PI) MODE

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                  45   OMEGA(1670) WIDTH (MEV)

W              112.      60.           ARMENISE   68 DBC    5.1 PI+N,P(3PI)0  9/68
W              100.      40.           KENYON     69 DBC    8.  PI+N,P(3PI)0  8/69
W     S 200    155.      40.           MATTHEWS   71 DBC    7.0 PI+N,P(3PI)0 11/75
W        500   167.      40.           DIAZ       74 DBC    6.  PI+N,P(3PI)0  1/74
W     Q 200    122.      39.           DIAZ       74 DBC    6.  PI+N,P(5PI)0  1/74
W  P S 600     173.      28.           WAGNER     75 HBC    7. PI+P,DEL++3PI 11/75
W  P E 430     173.0     16.0          BALTAY     78 HBC    15 PI+P,DEL 3PI   4/78*
W              253.0     39.0          CORDEN     78 OMEG   8-12 PI- P,N 3PI 12/77
W     S  60    160.0     80.0          BAUBILLIE 79 HBC     8.2K- P,BACKWARD 12/79*
W              . . . . . . . . . . .
W    AVG       166.1     12.0    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
W    STUDENT 165.4       12.2    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W     E   PHASE ROTATION SEEN FOR JP 3- (RHO PI) WAVE.
W  P      FROM A FIT TO I=0, JP=3- RHO PI PARTIAL WAVE
W     S   WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE
W     Q   FROM (OMEGA PI PI ) MODE

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                  45   OMEGA(1670) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      OMEGA(1670) INTO 3 PI (INCL. RHO PI)              134+ 134+ 134
P2      OMEGA(1670) INTO 5 PI (INCL. OMEGA PI+PI-)        134+ 134+ 134+ 134+
P3      CMEGA(1670) INTC RHO PI                           776+ 134
P4      CMEGA(1670) INTO OMEGA 2 PI                       782+ 134+ 134
P5      OMEGA(1670) INTO B(1235) PI                      1231+ 134

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                  45   OMEGA(1670) BRANCHING RATIOS

R1      OMEGA(1670) INTO (5 PI)/(3 PI)                   (P2)/(P1)
R1           (0.10)    (0.10)          KENYON     69 DBC    8.  PI+N,P(3PI)0. 8/69
R1      200    0.97      0.28          DIAZ       74 DBC    6.  PI+N,P(5PI)0  1/74

R2      OMEGA(1670) INTO (RHO PI)/(3 PI)                 (P3)/(P1)
R2      200   (0.70) OR MORE           MATTHEWS   71 DBC    7.0 PI+N,P(3PI)0 11/71

R3      OMEGA(1670) INTO (OMEGA 2 PI)/(RHO PI)           (P4)/(P3)
R3      100    0.71      0.27          DIAZ       74 DBC    6.  PI+N,P(5PI)0 12/78*

R4      OMEGA(1670) INTO (B(1235) PI)/(RHO PI)           (P5)/(P3)
R4          POSSIBLY SEEN              DIAZ       74 DBC    6.  PI+N,P(5PI)0  1/74

R5      OMEGA(1670) INTO (B(1235)PI)/(OMEGA PI PI)       (P5)/(P4)
R5            1.0       0.0        0.25  BAUBILLIE 79 HBC   8.2K- P,BACKWARD 12/79*

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REFERENCES FOR OMEGA(1670)


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ARMENISE 68 PL 26B 336            +GHIDINI,FORINO+ (BARI+BGNA  +FIRZ  +ORSAY)
KENYON   69 PRL 23 146            +KINSON,SCARR,+              (BNL+UCND+ORNL)
ARMENISE 70 LNC 4 199             +GHIDINI,FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)
MATTHEWS 71 PR D 3 2561           +PRENTICE,YOON,CARROLL,+          (TNTO+WISC)
MATTHEW1 71 LNC 1 361             +PRENTICE,YOON,CARROLL,+          (TNTO+WISC)
DIAZ     74 PRL 32 260            +DIBIANCA,FICKINGER,ANDERSON,+  (CASE+CARN)
WAGNER   75 PL 58B 201            +TABAK,CHEW                            (LBL)  JP
CERRADA  77 NP B 126 241          +BLOCKZIJL,HEINEN,+      (AMST+CERN+NIJM+OXF)  JP
BALTAY   78 PRL 40 87             +CAUTIS,KALELKAR                      (COLU)  JP
CORDEN   78 NP B 138 235          +CORBETT,ALEXANDER,+  (BIRM+RHEL+TELA+LOWC)
BAUBILLI 79 PL B 89 131           BAUBILLIER+        (BIRM+CERN+GLAS+MSU+LPNP)
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g(1700)

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15   G(1700,JPG = 3-+) I=1
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The g meson is uniquely established near 1700 MeV in the $I^GJ^P = 1^+3^-$ partial wave of the $\pi^+\pi^-$ system (HYAMS 75, MARTIN3 78, BECKER 79, CORDEN 79), in the K^+K^- system (GORLICH 79), and in the K^-K^0 system (MARTIN1,2 78). Its branching ratio into $\pi\pi$ is unanimously in the range 23-26%, whereas determinations of the ratio $K\bar{K}/\pi\pi$ are conflicting: 19.1% in a model-independent analysis of the K^+K^- system (GORLICH 79), but only 5.6% in K^-K^0 (MARTIN1,2 78). It is clear from these numbers, however, that the g decays predominantly into channels other than $\pi\pi$ or $K\bar{K}$, such as 4π, $\omega\pi$, $\rho\pi\pi$, $A_2\pi$, and $K\bar{K}\pi$.

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Data Card Listings

For notation, see key at front of Listings.

Mesons

g(1700)

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                    15   G MASS (MEV)

M        WE AVERAGE ONLY THE 2PI AND KKBAR MODES WHICH HAVE LARGE STATISTICS

M      2 PI MODE
M
M          (1700.0)  (100.0)             BELLINI   65 HLBC   0 6.1 PI-P          12/75
M          (1640.0)                      FORINO    65 DBC    0 4.5 PI+D           6/66
M           1670.0     30.0              GOLDBERG  65 HBC    0 6 PI+D, 8 PI-P
M          (1683.)    (13.)              ARMENISE  68 DBC    0 5.1 PI+ D        . 6/68
M           1640.0     25.0              CRENNELL  68 HBC   -  6.0 PI- P         12/68
M           1720.0     20.0              CRENNELL  68 HBC    0 6.0 PI- P         12/68
M          (1655.0)   (10.0)             JOHNSTON  68 HBC    0 7.0 PI- P        . 6/68
M           1737.0     23.0              ARMENISE  70 DBC    0 9 PI+ N            1/71
M       122 1650.0     35.0              BARTSCH   70 HBC  +  8 PI+ P,2 PI        5/70
M           1687.      21.               STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D   2/72
M           1678.      12.               MATTHEWS  71 DBC   0  7. PI+ N           2/72
M          (1652.)    (13.)              MATTHEWS  71 HBC   0  7. PI- P         . 2/72
M  E    600 1690.       7.               ENGLER    74 DBC    0 6. PI+N,PI+PI-P 12/75
M  GH      (1693.)    (8.)               GRAYER    74 ASPK   0 17 PI-P,PI+PI-N  2/74
M          (1632.)    (5.)               THOMPSON  74 HBC  +  13 PI+ P           12/75
M  GI      (1692.)    (12.)              ESTABROOK 75 RVUE     17 PI-P,PI+PI-N  12/75
M   I      (1722.)    (3.)               HYAMS     75 ASPK   0 17 PI-P,PI+PI-N 12/75
M       476 1679.0     11.0              BALTAY    78 HBC   0 15 PI+P,PI+PI-     4/78*
M           1716.0     58.0      29.0    BECKER    79 ASPK  0 17 PI- P PCLARIZ 12/79*
M    M      1734.0     10.0              CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79*
M
M  E     MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K* TYPED NOTE
M  G     USES SAME DATA AS HYAMS 75
M   H    INCLUDED IN BECKER 79 ANALYSIS
M   I    FROM PHASE-SHIFT ANALYSIS
M        ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTICNS
M    M   FROM A PHASE SHIFT SOLUTION CONTAINING A F PRIME WIDTH
M        TWO TIMES LARGER THAN THE K KBAR RESULT.
M
M      K KBAR + K KBAR PI MODE
M
M          (1675.)                       EHRLICH   66 HBC  +-  7.9 PI-P,K KBAR   2/72
M   K      (1700.)                       FRENCH    67 HBC    0 3,3.6 PBAR P       7/67
M          (1740.)                       FRENCH    67 HBC  (KO K+-) 3-4 PBAR P. 7/67
M           1640.0     20.0      25.0    CRENNELL  68 HBC  +-  6.0 PI-P,KBAR K 12/68
M           1690.0     16.0              ADERHOLZ  69 HBC  +    8 PI+ P,KKBARPI  8/69
M           1692.       6.               BLUM      75 ASPK   018.4 PI-P,N K+K- 11/75
M  P S   6K 1698.      12.               MARTIN 1  78 SPEC    10 PI P,KS K- P    4/78*
M    L     (1737.0)   (5.0)              EVANGELIS 79 OMEG    10. PI-P,K+ K- N 12/79*
M
M   K    OBSERVED IN NEUTRAL(K* KBAR) MODE  (G-PARITY UNKNOWN)
M    L   THEY CANNOT DISTINGUISH BETWEEN G AND OMEGA(1670).
M  P     FROM A FIT TO JP=3- PARTIAL WAVE.
M    S   SYSTEMATIC ERROR ON MASS SCALE SUBTRACTED
M
M           . . . . . . . . .
M   AVG     1693.2      5.5      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
M   STUDENT1691.0       3.8      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )

M      (4PI)+- MODE
M
M           1720.      15.               BALTAY    68 HBC  +   7, 8.5 PI+ P       6/68
M   J      (1675.0)   (10.0)             JOHNSTON  68 HBC   -  7.0 PI- P          6/68
M       144 1680.0     40.0              BARTSCH   70 HBC  +  8 PI+ P,4 PI        4/71
M        90(1640.0)   (20.0)             BARTSCH   70 HBC  +  8 PI+ P,A2 PI       4/71
M   F   102(1689.0)   (20.0)             BARTSCH   70 HBC  +  8 PI+ P,2 RHO       4/71
M           1705.0     21.0              CASO      70 HBC   - 11.2PI-P,RHO 2PI    5/70
M       300(1710.)                       ARMENISE  72 HBC  -  9.1 PI- P,P 4PI   12/72
M           1630.      15.               HOLMES    72 HBC  +  10.-12. K+ P        1/73
M           1687.      20.               CASON     73 HBC  -  8.,18.5 PI- P       1/74
M   F      (1685.)    (14.)              CASON     73 HBC  -  8.,18.5 PI- P       1/74
M   F    66(1733.)    (9.)               KLIGER    74 HBC   - 4.5 PI-P,P 4PI    12/75
M           1670.      10.               THOMPSON  74 HBC  +  13 PI+ P           12/75
M       177 1665.0     15.0              BALTAY    78 HBC  +  15 PI+P,P 4PI      4/78*
M           . . . . . . . . .
M   AVG     1675.2     11.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
M   STUDENT1674.9       7.8      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )

M   F    FROM (RHO+- RHOO) MODE
M   J    NOT SEPARATED FROM 2 PI DECAY

M      RHCO RHOO MODE
M
M          (1700.0)                      MAURER    70 HBC     05.7 PBAR P,7 PI . 2/71
M          (1700.0)                      BRAUN     71 HBC     05.7 PBAR P,7 PI  11/71

M      OMEGA PI  MODE
M
M           1654.      24.               BARNHAM   70 HBC  +  10 K+ P,OMEGA PI  6/70
M           1630.0     11.0              CASO      70 HBC   - 11.2PI-P,PI OMEG  5/70
M          (1666.)    (50.)              CASON     73 HBC  -  8.,18.5 PI- P       1/74
M           1686.       9.               THOMPSON  74 HBC  +  13 PI+ P           12/75
M           1666.0     14.0              GESSAROLI 77 HBC     11 PI-P,OMEGA PI 12/77
M           . . . . . . . . .
M   AVG     1663.4     13.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
M   STUDENT1665.7      10.2      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )

M       R PEAKS FROM MMS. (FOR DIFFICULTIES WITH MMS EXPTS. SEE
M                         THE A2 MINI-REVIEW IN THE 1973 EDITION)
M
M  NR1     (1632.)    (15.)              FOCACCI   66 MMS   -    7-12 PI-P,P MMS 12/72
M  NR2     (1700.)    (15.)              FOCACCI   66 MMS   -    7-12 PI-P,P MMS 12/72
M  NR3     (1748.)    (15.)              FOCACCI   66 MMS   -    7-12 PI-P,P MMS 12/72
M  N     NOT SEEN BY BOWEN 72
M   R      (1700.0)   (47.0)             ANDERSON  69 MMS    -  16 PI- P,BACKW    8/69
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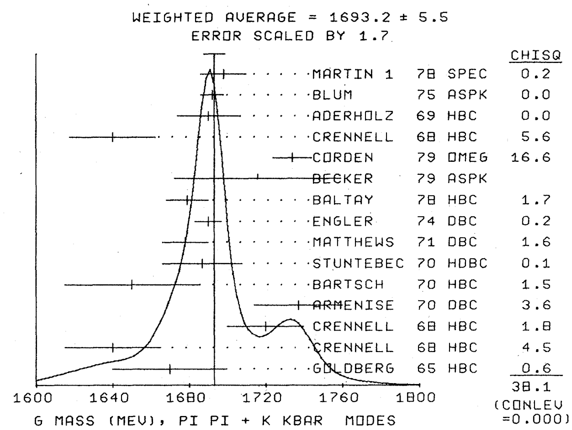

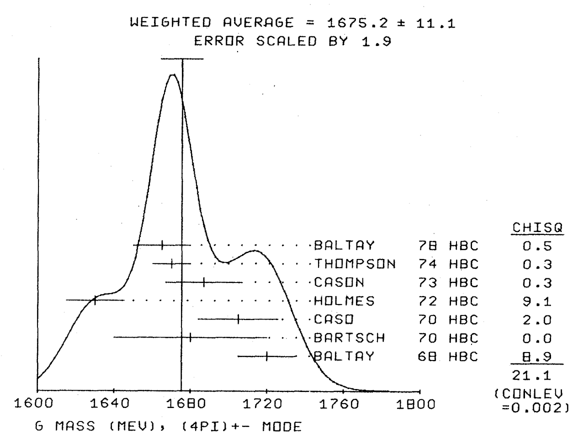

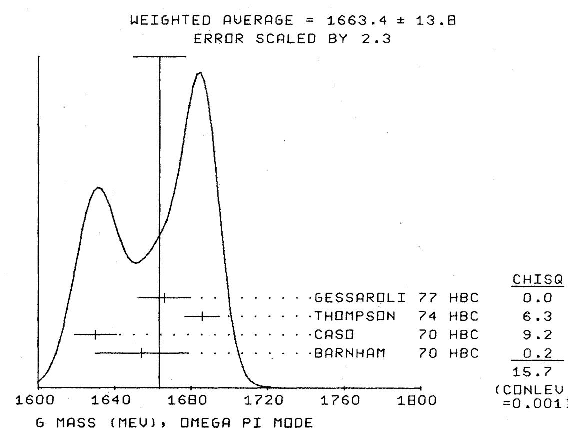

Mesons
g(1700)

Data Card Listings
For notation, see key at front of Listings.

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                 15  G WIDTH (MEV)
W      WE AVERAGE ONLY THE 2PI AND KKBAR MODES WHICH HAVE LARGE STATISTICS
W
W     2 PI MODE
W
W            (40.0)                      FORINO     65 DBC    0 4.5 PI+D          6/66
W            180.0     40.0              GOLDBERG   65 HBC    0 6 PI+D, 8 PI-P
W            188.      49.               ARMENISE   68 DBC    0 5.1 PI+ D         6/68
W            200.0    100.0              CRENNELL   68 HBC    - 6.0 PI- P        12/68
W            200.0    100.0              CRENNELL   68 HBC    0 6.0 PI- P        12/68
W            (80.0)   (20.0)             JOHNSTON   68 HBC    0 7.0 PI- P       . 6/68
W            171.0     65.0              ARMENISE   70 DBC    0 9 PI+ D           1/71
W       122  180.0     30.0              BARTSCH    70 HBC  +  8 PI+ P,2 PI       5/70
W            267.      72.       46.     STUNTEBEC  70 HDBC  0 8. PI-P,5.4 PI+D  2/72
W            156.      36.               MATTHEWS   71 DBC    0  7. PI+ N         2/72
W            (73.)    (36.)              MATTHEWS   71 HBC    0  7. PI- P       . 2/72
W       600  167.      40.               ENGLER     74 DBC    0 6. PI+N,PI+P-P 12/75
W  GH       (200.)    (18.)              GRAYER     74 ASPK   0 17 PI-P,PI+PI-N  2/74
W            (42.)    (20.)              THOMPSON   74 HBC  +  13 PI+ P          12/75
W  GI       (240.)    (30.)              ESTABROOK  75 RVUE    17 PI-P,PI+PI-N  12/75
W  I        (267.)    (30.)              HYAMS      75 ASPK   0 17 PI-P,PI+PI-N 12/75
W       476  116.0     30.0              BALTAY     78 HBC    0 15 PI+P,PI+PI-   4/78*
W           (206.0)  OR MORE  CL=.84     BECKER     79 ASPK   0 17 PI- P POLARIZ 12/79*
W   M        322.0     35.0              CORDEN     79 OMEG     12-15PI-P, N 2PI 12/79*
W
W   H   INCLUDED IN BECKER 79 ANALYSIS
W   I   FROM PHASE-SHIFT ANALYSIS
W       ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
W   G   USES SAME DATA AS HYAMS 75
W   M   FROM A PHASE SHIFT SOLUTION CONTAINING A F PRIME WIDTH
W         TWO TIMES LARGER THAN THE K KBAR RESULT.
W
W     K KBAR + K KBAR PI MODE
W
W            79.0      70.0              CRENNELL   68 HBC  +-  6.0 PI-P,KBAR K 12/78*
W            112.0     60.0              ADERHOLZ   69 HBC  +   8 PI+ P,KKBARPI   8/69
W            205.      20.               BLUM       75 ASPK   018.4 PI- P,N K+K- 11/75
W  P   6000  199.      40.               MARTIN 1   78 SPEC    10 PI P,KS K- P   4/78*
W  P         FROM A FIT TO JP=3- PARTIAL WAVE.
W   L       (214.0)   (20.0)             EVANGELIS 79 OMEG     10. PI-P,K+ K- N 12/79*
W   L   THEY CANNOT DISTINGUISH BETWEEN G AND OMEGA(1670).
W
W            . . . . . . . . .
W  AVG       188.5     14.4      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
W  STUDENT 184.3       12.5      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                 (SEE IDEOGRAM BELOW )
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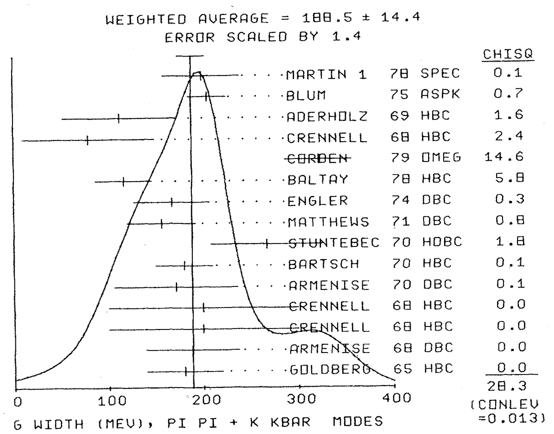


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W     (4PI)+- MODE
W
W            100.      35.               BALTAY     68 HBC  +   7, 8.5 PI+ P      6/68
W   J        (90.0)   (20.0)             JOHNSTON   68 HBC  -   7.0 PI- P         6/68
W       144  135.0     30.0              BARTSCH    70 HBC  +  8 PI+ P,4 PI       4/71
W        90 (180.0)   (30.0)             BARTSCH    70 HBC  +  8 PI+ P,A2 PI      4/71
W   F   102 (160.0)   (30.0)             BARTSCH    70 HBC  +  8 PI+ P,2 RHO
W           (160.0)                      CASO       70 HBC  - 11.2PI-P,RHO 2PI    5/70
W       300 (200.)                       ARMENISE   72 HBC  -  9.1 PI- P,P 4PI   12/72
W            130.      30.               HOLMES     72 HBC  +  10.-12. K+ P       1/73
W            169.      70.       48.     CASCN      73 HBC  -  8.,18.5 PI- P      1/74
W   F       (125.)    (83.)     (35.)    CASON      73 HBC  -  8.,18.5 PI- P      1/74
W   F    66 (150.)                       KLIGER     74 HBC  -  4.5 PI-P,P 4PI    12/75
W            106.      25.               THOMPSON   74 HBC  +  13 PI+ P          12/75
W       177  105.0     30.0              BALTAY     78 HBC  +  15 PI+P,P 4PI      4/78*
W            . . . . . . . . .
W  AVG       117.8     12.9      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W  STUDENT 117.6       14.1      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W   F   FROM (RHO+- RHO0) MODE
W   J       NOT SEPARATED FROM 2 PI DECAY

W     OMEGA PI  MODE
W
W            130.      73.       43.     BARNHAM    70 HBC  +  10 K+ P,OMEGA PI  6/70
W            (60.0)                      CASO       70 HBC  - 11.2PI-P,PI OMEG  5/70
W           (194.)    (94.)     (60.)    CASON      73 HBC  -  8.,18.5 PI- P      1/74
W            89.       25.               THOMPSON   74 HBC  +  13 PI+ P          12/75
W            160.0     56.0              GESSAROLI  77 HBC     11 PI-P,OMEGA PI 12/77
W            . . . . . . . . .
W  AVG       104.7     21.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W  STUDENT 104.4       24.0      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W     R PEAKS FROM MMS. (FOR DIFFICULTIES WITH MMS EXPTS. SEE
W                       THE A2 MINI-REVIEW IN THE 1973 EDITION)
W
W  NR1       (21.)    OR LESS            FOCACCI    66 MMS  -   7-12 PI-P,P MMS 12/72
W  NR2       (30.)    OR LESS            FOCACCI    66 MMS  -   7-12 PI-P,P MMS 12/72
W  NR3       (38.)    OR LESS            FOCACCI    66 MMS  -   7-12 PI-P,P MMS 12/72
W  N     NOT SEEN BY BOWEN 72
W  R         (195.0)                     ANDERSON   69 MMS  -   16 PI- P,BACKW    8/69
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                 15  G PARTIAL DECAY MODES

                                                              DECAY MASSES
P1       G INTO PI PI                                         139+ 139
P2       G INTO 4PI(INCL. PIO'S)                              139+ 139+ 139+ 139
P3       G INTO K KBAR PI                                     497+ 497+ 139
P4       G INTO K KBAR                                        497+ 497
P5       G INTO PI PI RHO (EXCLUDING 2RHO+A2 PI)              139+ 139+ 776
P6       G INTO A2 PI                                         1317+ 139
P7       G INTO OMEGA PI                                      139+ 782
P8       G INTO 2 RHO                                         776+ 776
P9       G INTO PHI PI                                        1019+ 139
P10      G INTO ETA PI                                        548+ 139
P11      G+- INTO  3 PI CHARGED AND 1 PIO                     139+ 139+ 139+ 139
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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{(\delta P_i \delta P_i)}$, while the off-diagonal elements are the normalized correlation coefficients $(\delta P_i \delta P_j)/(\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

```
        P 1        P 2        P 3        P 4
 P 1 .2401+-.0126
 P 2   -.8706  .7209+-.0160
 P 3    .1625    -.5844  .0239+-.0073
 P 4    .0584    -.2517     .0089  .0151+-.0032
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                 15  G BRANCHING RATIOS

R1       G INTO (2PI)/TOTAL                                    (P1)
R1             (0.4)                      BARTSCH    70 HBC  +  8. PI+ P         . 2/72
R1    P         0.22      0.04            MATTHEWS   71 HDBC  0  7. PI+N,PI-P      2/72
R1   G         (.245)    (.006)           ESTABROOK  75 RVUE    17 PI-P,PI+PI-N  12/75
R1  SH         (.24)     (.01)            HYAMS      75 ASPK    0 17 PI-P,PI+PI-N 12/75
R1              0.259     0.018    0.019  BECKER     79 ASPK  0 17 PI- P POLARIZ 12/79*
R1              0.23      0.02            CORDEN     79 OMEG     12-15PI-P, N 2PI 12/79*
R1   G    FROM PHASE-SHIFT ANALYSIS OF HYAMS 75 DATA
R1   H    INCLUDED IN BECKER 79 ANALYSIS
R1   P    CPE MODEL USED IN THIS ESTIMATION
R1 S      ERROR TAKES ACCOUNT OF SPREAD OF 4 DIFFERENT PHASE-SHIFT SOLUTIONS
R1              . . . . . . . . .
R1   AVG        0.243     0.013    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1   STUDENT    0.243     0.015    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1   FIT        0.240     0.013   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2       G INTO(2 PI)/(4 PI) CHARGED                           (P1)/(P11)
R2             (0.8)     (0.15)           BARTSCH    70 HBC  +  8. PI+ P         . 2/72
R2             (0.12) OR LESS             BALLAM     71 HBC  -    16. PI- P      . 2/72
R2             (0.2)  OR LESS             HOLMES     72 HBC  +  10.-12. K+ P       1/73
R2              0.35      0.11            CASCN      73 HBC  -  8.,18.5 PI- P      1/74
R2              2.3       1.0             KALELKAR   75 HBC     015 PI+P          12/78*
R2              . . . . . . . . .
R2   AVG        0.37      0.11     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2   STUDENT    0.37      0.12     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R3       GO INTO(2 PI)/(4 PI) ALL                              (P1)/(P2)
R3              0.30      0.10            BALTAY     78 HBC    0 15 PI+P,P 4PI    4/78*
R3              . . . . . . . . .
R3   FIT        0.333     0.024   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4       G+- INTO (K KBAR)/(2PI)                               (P4)/(P1)
R4              0.08      0.08     0.03   CRENNELL   68 HBC      6.0 PI- P        12/68
R4              0.08      0.03            BARTSCH    70 HBC  +   8. PI+ P        . 1/71
R4             (0.191)   (0.040)  (0.037)GORLICH    79 ASPK  0 17,18 PI-P POLAR 12/79*
R4              . . . . . . . . .
R4   AVG        0.080     0.026    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4   STUDENT    0.080     0.028    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R4   FIT        0.063     0.014   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5       G+- INTO (K KBAR PI)/(2PI)                            (P3)/(P1)
R5              0.10      0.03            BARTSCH    70 HBC  +  8. PI+ P         . 2/72
R5              . . . . . . . . .
R5   FIT        0.100     0.030   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6       G+- INTO (RHO 2PI)/(4 PI) CHARGED                     (P5+P6+P8)/(P11)
R6             CONSISTENT WITH 1.         CASO       68 HBC  -   11 PI- P          6/68
R6             (1.)      (0.15)           BARTSCH    70 HBC  +  8. PI+ P         . 2/72
R6              0.88      0.15            BALLAM     71 HBC  -    16. PI- P        2/72
R6              0.96      0.21            BALTAY     78 HBC  +  15 PI+P,P 4PI     4/78*
R6              . . . . . . . . .
R6   AVG        0.91      0.12     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6   STUDENT    0.91      0.13     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R7       G+- INTO (2RHO)/(4 PI) CHARGED                        (P8)/(P11)
R7             (0.7)     (0.15)           BARTSCH    70 HBC  +  8. PI+ P         . 2/72
R7             (0.92)                     ARMENISE   72 HBC  -  9.1 PI- P,P 4PI  12/72
R7   A         (0.78)    (0.33)           CASON      73 HBC  -  8.,18.5 PI- P      1/74
R7   A     ASSUMING (ALL 4PI)=(RHO RHO) + (OMEGA PI)
R7        66   (.56)                      KLIGER     74 HBC   - 4.5 PI-P,P 4PI   12/75
R7   T         (0.13)    (0.09)           THOMPSON   74 HBC  +  13 PI+ P          12/75
R7              0.12      0.11            BALTAY     78 HBC  +  15 PI+P,P 4PI     4/78*
R7   T    RHO RHO AND A2 PI MODES ARE INDISTINGUISHABLE

R8       G+- INTO (2 RHO)/(ALL RHO 2PI)                        (P8)/(P5+P6+P8)
R8              0.48      0.16            CASO       68 HBC  -   11 PI- P          6/68
R8             (0.75) OR MORE             BISWAS     68 HBC  -   8. PI- P          2/72

R9       G+- INTO (PI A2)/(4 PI) CHARGED                       (P6)/(P11)
R9             (0.6)                      BALTAY     68 HBC  +    7,8.5 PI+P       6/68
R9              NOT SEEN                  JOHNSTON   68 HBC   - . 7 PI- P          6/68
R9             (0.6)     (0.15)           BARTSCH    70 HBC  +  8. PI+ P         . 2/72
R9              NOT SEEN                  CASON      73 HBC  -  8.,18.5 PI- P      1/74
R9   T         (0.36)    (0.14)           THOMPSON   74 HBC  +  13 PI+P           4/78*
R9              0.66      0.08            BALTAY     78 HBC  +  15 PI+P,P 4PI     4/78*
R9   T    RHO RHO AND A2 PI MODES ARE INDISTINGUISHABLE

R10      G+- INTO (PI OMEGA)/(4 PI) CHARGED                    (P7)/(P11)
R10             0.25      0.10            BALTAY     68 HBC  +   7-8.5 PI+P        5/68
R10              .25      0.10            JOHNSTON   68 HBC  -   7.0 PI- P         6/68
R10             0.12      0.07            BALLAM     71 HBC  -    16. PI- P        2/72
R10  A         (0.22)    (0.08)           CASON      73 HBC  -  8.,18.5 PI- P      1/74
R10  A     ASSUMING (ALL 4PI)=(RHO RHO) + (OMEGA PI)
R10            (.09) OR LESS              KLIGER     74 HBC   - 4.5 PI-P,P 4PI   12/75
R10             0.33      0.07            THOMPSON   74 HBC  +  13 PI+ P          12/75
R10            (0.11) OR LESS  CL=0.95    BALTAY     78 HBC  +  15 PI+P,P 4PI     4/78*
R10             . . . . . . . . .
R10  AVG        0.233     0.050    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R10  STUDENT    0.236     0.051    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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Data Card Listings

For notation, see key at front of Listings.

Mesons

g(1700), X(1690), $A_4(1900)$

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R11     G+- INTO (PI PHI)/(4 PI) CHARGED                 (P9)/(P11)
R11          (0.11) OR LESS          BALTAY    68 HBC  +    7,8.5 PI+P        6/68

R12     G+- INTO (PI+- 2PI+ 2PI- PI0)/(4 PI) CH.
R12          (0.15) OR LESS          BALTAY    68 HBC  +    7,8.5 PI+ P       6/68

R13     G+- INTO (PI ETA)/(4 PI) CHARGED                 (P10)/(P11)
R13          (0.02) OR LESS          THOMPSON  74 HBC  +  13 PI+ P           12/75

R14     G+- INTO (K KBAR)/TOTAL                          (P4)
R14  B          0.013     0.004      MARTIN 2  78 SPEC   -10 PI P,KS K- P    4/78*
R14  B   FROM SQRT(P1*P4)=0.056+-0.034 ASSUMING (2PI)/TOTAL=P1=0.24
R14             . . . . . . . . .
R14 FIT         0.0151    0.0032 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R15     G+- INTO (2PI)/(2RHO)                            (P1)/(P8)
R15 S          (0.48) OR LESS        BISWAS    68 HBC  -    8. PI- P         12/78*
R15 S    SUPERSEDED BY CASON 73

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REFERENCES FOR G


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BELLINI  65 NC 40 A 948          BELLINI,DI CCRATO,DUIMIC,FIORINI    (MILANO)
DEUTSCHM 65 PL 18 351            M.DEUTSCHMANN ET AL     (AACHEN+BERLIN+CERN)
FORINO   65 PL 19 65             FORINO,GESSAROLI +    (BOLOGNA+ORSAY+SACLAY)
GOLDBERG 65 PL 17 354            GOLDBERG+ (CERN+EPOL+ORSAY+MILANO+CEA-SACL)

EHRLICH  66 PR 152 1194          R. EHRLICH,W.SELOVE,H.YUTA    (PENNSYLVANIA)
FOCACCI  66 PRL  17  890         CERN MISSING MASS SPECTROMETER GROUP (CERN)
LEVRAT   66 PL  22  714          CERN MISSING MASS SPECTROMETER GROUP (CERN)
SEGUINOT 66 PL 19 712            CERN MISSING MASS SPECTROMETER GROUP (CERN)

ABRAMS   67 PRL 18 620           +KEHOE+GLASSER+SECHI-ZORN+WOLSKY (MARYLAND)
DANYSZ   67 PL 24B 309           +FRENCH+KINSON+SIMAK+       (CERN+LIVERPOOL)
DUBAL    67 NP B3 435            +FOCACCI+KIENZLE+LECHANOINE+LEVRAT+  (CERN)
   ALSO  68 THESIS 1456          L.DUBAL                             (GENEVE)
FRENCH   67 NC 52A 442           +KINSON+MCDONALD+RIDDIFORD+     (CERN+BIRM)

ARMENISE 68 NC 54 A 999          +FORINO+CARTACCI+(BARI+BGNA +FIRENZE+ORSAY)I
BALTAY   68 PRL 20 887           +KUNG+YEH+FERBEL+      (COLU+ROCH+RUTG+YALE)I=1
BISWAS   68 PRL 21 50            +CASON,DZIERBA,GROVES,KENNEY,+         (NDAM)
BOESEBEC 68 NP B 4 501           BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO     68 NC 54 A 983          +CONTE+CORDS+DIAZ+  (GENOVA+HAMB+MILA+SACL)
CRENNELL 68 PL 28 B 136          +KARSHON,LAI,SCARR,SKILLICORN           (BNL)
JOHNSTON 68 PRL 20 1414          +PRENTICE,STEENBERG,YOON     (TORONTO+WISC)IJP

ADERHOLZ 69 NP B 11 259          +BARTSCH,+        (AACH+BERL+CERN+JAGL+WARS)
ANDERSON 69 PRL 22 1390          +COLLINS,BLIEDEN+                  (BNL+CARN)
BARISH   69 PR 184  1375         +SELOVE,BISWAS,CASON,+      (PENN+NDAM+ROCH)
CASO     69 NC 62 A 755          +CONTE,BENZ,+      (GENO+DESY+HAMB+MILA+SACL)
VETLITSK 69 SJNP 9 461           +GUZHAVIN,KLIGER,KOLGANOV,LEBEDEV+    (ITEP)

ARMENISE 70 LNC 4  199           +GHIDINI,FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)
BARNHAM  70 PRL 24 1083          +COLLEY,JOBES,KENYON,PATHAK,RIDDIFORD(BIRM)
BARTSCH  70 NP B 22 109          +KRAUS,TSANOS,GROTE,KOTZAN+(AACH+BERL+CERN)
CASO     70 LNC 3 707            +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
KRAMER   70 PRL 25 396           +BARTON,GUTAY,LICHTMAN,MILLER,+    (PURDUE)
MAURER   70  THESIS NO.588       G.MAURER                        (STRASBOURG)
STUNTEBE 70 PL 32 B 391          STUNTEBECK,KENNEY,DEERY,BISWAS,CASON+(NDAM)

BALLAM   71 PR D 3 2606          +CHADWICK,GUIRAGOSSIAN,JOHNSON,+      (SLAC)
BRAUN    71 NP B 30 213          +FRIDMAN,GERBER,GIVERNAUD,KAHN,+      (STRB)
GRAYER   71 PL 35 B 610          +HYAMS,JONES,SCHLEIN,BLUM,+      (CERN+MPIM)JP3-
MATTHEWS 71 NP B 331             +PRENTICE,YOON,CARROLL,+         (TNTO+WISC)JP3-

ARMENISE 72 LNC 4 205            +FORINO,CARTACCI,+          (BARI+BGNA+FIRZ)
   ALSO  75 LNC 14 177           +FOGLI-MUCIACCIA,FORINO+    (BARI+BGNA+FIRZ)  JP
BOWEN    72 PRL 29 890           +EARLES,FAISSLER,BLIEDEN,+        (NEAS+STON)
CLAYTON  72 NP B 47 81           +MASON,MUIRHEAD,RIGOPOULOS,+      (LIVP+PATR)
GRAYER   72 PHIL.CONF.PROC. 5 +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
HOLMES   72 PR D 6 3336          +FERBEL,SLATTERY,WERNER                (ROCH)

ARNOLD   73 LNC 6 707            +ENGEL,ESCOUBES,KURTZ,LLORET,PATY,+   (STRB)
CASON    73 PR D 7 1971          +BISWAS,KENNEY,MADDEN,SANDER,SHEPHARD(NDAM)
CASON 1  73 NP B 64 14           +MADDEN,BISHOP,BISWAS,KENNEY,+         (NDAM)
HYAMS    73 NP B 64 134          +JONES,WEILHAMMER,BLUM,DIETL,+  (CERN+MPIM)
ROBERTSO 73 PR D 7 2554          ROBERTSON,WALKER,DAVIS            (DUKE+WISC)

DUBOVIKO 74 SJNP 19 568          DUBOVIKOV,MATSYUK,NILOV,SOKOLOV       (ITEP)
ENGLER   74 PR D10 2070          +KRAEMER,TOAFF,WEISSER,DIAZ+     (CARN+CASE)
GRAYER   74 NP B 75 189          G.GRAYER,HYAMS,BLUM,DIETL,+      (CERN+MPIM)
KLIGER   74 SJNP 19 428          +BEKETOV,GRECHKO,GUZHAVIN,DUBOVIKOV+ (ITEP)
OREN     74 NP B71 189           +COOPER,FIELDS,RHINES,WHITMORE,+  (ANL+OXF)
THOMPSON 74 NP B69 220           +GAIDOS,MCILWAIN,MILLER,MULERA,+      (PURD)

BLUM     75 PL 57B 403           +CHABAUD,DIETL,GARELICK,GRAYER+ (CERN+MPIM) JP
ESTABROO 75 NP B95 322           P.ESTABROOKS,A.D.MARTIN               (DURH)
HYAMS    75 NP B100 205          +JONES,WEILHAMMER,BLUM,DIETL+   (CERN+MPIM)
KALELKAR 75 THESIS(NEVIS 207) M.S.KALELKAR                        (COLU)I=1

ANTIPOV  77 NP B 119 45          +BUSNELLO,DAMGAARD,KIENZLE+      (CERN+SERP)
GESSAROL 77 NP B 126 382         GESSAROLI,+  (BGNA+FIRZ+GENO+MILA+OXF+PAVI)

BALTAY   78 PR D 17 62           +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
FORINO   78 NP B 139 413         +CARTACCI,+  (BGNA+FIRZ+GENO+MILA+OXF+PAVI)  JP
MARTIN 1 78 PL 74 B 417          +OZMUTLU+BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)
MARTIN 2 78 NP B 140 158         +OZMUTLU,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)
MARTIN 3 78 ANP  114 1           A.D.MARTIN,M.R.PENNINGTON             (CERN)

BECKER   79 NP B 151  46         +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN   79 NP B 157 250         +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC)  JP
EVANGELI 79 NP B 154 381         + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)
GORLICH  79  CERN/EP 79-139      +NICZYPORUK,ROZANSKA+ (CRAC+MPIM+CERN+ZEEM)
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X(1690)

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64  X(1690)

THIS ENTRY CONTAINS CMEGA PI PI PEAKS AROUND
1690 MEV. EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.

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                 64  X(1690) MASS (MEV)

M   N     (1689.)     (10.)          DANYSZ    67 HBC    0 3,3.6 PBAR P     2/74
M   N   NOT SEEN IN HIGH STATISTICS EXP. OF OREN 74
M        (1670.0)    (18.0)          YOST      68 HBC    04.3 K-P,LMBD.5PI. 2/74
M          1695.0     20.0           BARNES    69 HBC    0 4.6 K-P,OMEG2PI  2/74

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                 64  X(1690) WIDTH (MEV)

W   N       (38.)    (18.)           DANYSZ    67 HBC    0 3,3.6 PBAR P     1/73
W   N   NOT SEEN IN HIGH STATISTICS EXP. OF OREN 74
W          (50.0)    (15.0)          YOST      68 HBC    04.3 K-P,LMBD.5PI. 1/73
W           90.       20.            BARNES    69 HBC    0 4.6 K-P,OMEG2PI  1/73

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REFERENCES FOR X(1690)


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DANYSZ   67 NC 51 A 801          DANYSZ+FRENCH+SIMAK                   (CERN)
YOST     68  UMD  T.REPORT849 +YODH,EINSCHLAG,DAY,GLASSER               (UMD)
BARNES   69 PRL 23 142           +CHUNG,EISNER,FLAMINIO,+               (BNL)
OREN     74 NP B71 189           +COOPER,FIELDS,RHINES,WHITMORE,+  (ANL+OXF)   .
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$A_4(1900)$

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43  A4(1900,JPG=  -)  I=1

THIS ENTRY CONTAINS THE DIFFRACTIVE-LIKE 3PI AND 5PI
BUMPS IN THE REGION OF 1900 MEV, AS WELL AS VARIOUS
PEAKS NEARBY. NOTE THAT THE EXISTENCE OF AN S-WAVE
GPI THRESHOLD BUMP (IN ANALOGY TO A1 AND A3)
IS NOT UNEXPECTED. OMITTED FROM TABLE.

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                 43  A4 MASS  (MEV)

M          (1900.)                   HUSON     68 HLBC -  16.PI-A,A 5PI      2/74
M          (1830.)                   SALZBERG  72 HBC  -  13,20 PI-P,P 3PI   2/74
M   B    40(1960.)     (30.)         BASTIEN   73 DBC  -  15.PI-D,D 3PI      2/74
M          (1800.)                   DEUTSCHM  75 HBC  +  16 PI+P,P 3PI     12/75
M   C   208(2C80.)     (40.)         KALELKAR  75 HBC  +  15 PI+P,P PI+G    12/75
M          (2100.)    APPROX         ANTIPOV   77 CIBS -  25PI-P,P 3PI      12/77
M          (2214.)     (15.)         BALTAY    77 HBC   0 15PI-P,DEL++3PI   12/77

M       VARIOUS PEAKS
M   K      (1820.)     (12.)         FRENCH    67 HBC    0 3,3.6 PBAR P      7/67

M   B   MARGINAL STATISTICAL SIGNIFICANCE.
M   C   SAME EXPERIMENT AS BALTAY 77
M   K   OBSERVED IN (KS KO PIO...) MODE  (G-PARITY UNKNOWN)
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                     A4  WIDTH  (MEV)

W          (130.)                    SALZBERG  72 HBC  -  13,20 PI-P,P 3PI   2/74
W   B   40 (200.)                    BASTIEN   73 DBC  -  15.PI-D,D 3PI      2/74
W   C  208 (340.)      (80.)         KALELKAR  75 HBC  +  15 PI+P,P PI+G    12/75
W          (500.)    APPROX.         ANTIPOV   77 CIBS -  25PI-P,P 3PI      12/77
M          (355.)      (21.)         BALTAY    77 HBC   0 15PI-P,DEL++3PI   12/77

W       VARICUS PEAKS
W   K        (50.)     (20.)         FRENCH    67 HBC    0 3-4 PBAR P        7/67

W   B   MARGINAL STATISTICAL SIGNIFICANCE.
W   C   SAME EXPERIMENT AS BALTAY 77
W   K   SEE NOTE K ABOVE

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                 43  A4 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      A4 INTO 3PI                                     139+ 139+ 139
P2      A4 INTO RHO PI                                  776+ 139
P3      A4 INTC F PI                                   1273+ 139
P4      A4 INTO G PI                                   1700+ 139

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                 43  A4 BRANCHING RATIOS

R1      A4 INTC (G PI)/(ALL 3PI)                         (P4)/(P1)
R1           DOMINANT                KALELKAR  75 HBC  +  15 PI+P,P 3PI     12/75

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REFERENCES FOR A4


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DANYSZ   67 NC 51A 801           DANYSZ+FRENCH+SIMAK                   (CERN)
FRENCH   67 NC 52A 442           +KINSON+MCDCNALD+RIDDIFORD+     (CERN+BIRM)

HUSCN    68 PL 28 B 208          +LUBATTI,BELLINI,BINGHAM,+  (ORSA+MILA+LBL)

BEMPCRAD 71 NP B 33 397          +DUFEY,CODLING,+         (CERN+ETH+LOIC+MILA)

CLAYTON  72 NP B 47 81           +MASON,MUIRHEAD,RIGOPOULOS,+      (LIVP+PATR)
HARRISON 72 PRL 28 775           +HEYDA,JOHNSON,KIM,LAW,MUELLER,+       (HARV)
SALZBERG 72 NP B 41 397          +HARRISON,HEYDA,JOHNSON,KIM,LAW,+      (HARV)

BASTIEN  73 UPPSALA CONF. 73  +DUNN,HARRIS,LUBATTI,BINGHAM,+    (SEAT+UCB)

OREN     74 NP B71 189           +COOPER,FIELDS,RHINES,WHITMORE,+  (ANL+CXF)   .

DEUTSCHM 75 NP B99 397           DEUTSCHMANN,+        (ABBCCHW COLLABORATION)
KALELKAR 75 THESIS(NEVIS 207) M.S.KALELKAR                             (COLU)   .

ANTIPOV  77 NP B 119 45          +BUSNELLO,DAMGAARD,KIENZLE+      (CERN+SERP)
BALTAY   77 PRL 39 591           +CAUTIS,KALELKAR                  (COLUMBIA)  JP
CAUTIS   77  THESIS NEVIS 221 C.V.CAUTIS                           (COLUMBIA)  JP

BALTAY   78 PR D 17 52           +CAUTIS,COHEN,CSORNA,KALELKAR+  (COLU+BING)
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Mesons

$A_2(1900)$, S(1935)

Data Card Listings

For notation, see key at front of Listings.

$A_2(1900)$

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17  A2(1900,JPG=4+-) I=1

THIS ENTRY CONTAINS THE STRUCTURES FOUND WITH A
MOMENTS ANALYSIS OF THE KS K- SYSTEM AND WITH
A PARTIAL WAVE ANALYSIS OF THE NEUTRAL 3 PI
SYSTEM.
WAIT CONFIRMATION. OMITTED FROM TABLE.

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                17  A2(1900) MASS (MEV)

M    Y      1903.0     10.0               BALDI      78 SPEC -  10 PI-P,P KS K-   12/77
M    M      2C30.0     50.0               CORDEN     78 OMEG  0 15 PI- P,3 PI N   12/78*
M           . . . . . . . . .
M   AVG     1907.9      9.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1906.3      10.9      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M    M  JP=4+ IS FAVOURED , THOUGH 2+ CAN NOT BE EXCLUDED.                         12/78*
M    Y  FRCM A FIT TO THE Y(8,0) MOMENT.
M

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                17  A2(1900) WIDTH (MEV)

W    Y       166.0     43.0               BALDI      78 SPEC -  10PI-P,P KS K-    12/77
W    M       510.0    200.0               CORDEN     78 OMEG  0 15 PI- P,3 PI N   12/78*
W           . . . . . . . . .
W   AVG      181.2     42.0      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W   STUDENT 178.6      46.4      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W    M  JP=4+ IS FAVOURED , THOUGH 2+ CAN NOT BE EXCLUDED.                         12/78*
W    Y  FROM A FIT TO THE Y(8,0) MOMENT.
W

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                       REFERENCES FOR A2(1900)

BALDI     78 PL 74 B 413        +BOHRINGER,DORSAZ,HUNGERBULER,+     (GENEVA)  JP
CORDEN    78 NP B 136 77        DOWELL,GARVEY,JOBES+  (BIRM+RHEL+TELA+LOWC)  JP

CCRDEN    78 NP B 136 77        DOWELL,GARVEY,JOBES+  (BIRM+RHEL+TELA+LOWC)  JP

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S(1935)

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31  S(1935,JPG=  )
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A narrow enhancement has been observed in the antiproton-proton total cross section, called the S(1935) (CARROL 74, CHALOUPKA 76, BRUCKNER 77). The three experiments are in reasonable agreement on the mass and width (see the Data Card Listings below) and on the size of the enhancement above background. However, CHALOUPKA 76 finds a large elasticity, whereas BRUCKNER 77 observes the enhancement mainly in the annihilation channels. SAKAMOTO 79 sees a narrow enhancement compatible with CARROLL 74, CHALOUPKA 76, and BRUCKNER 77, but of more limited statistical significance.

Considerable doubt has been cast on the existence of the S(1935) as a narrow state by new measurements of the antiproton-proton total cross section. KAMAE 80 see no effect at all. With much better statistics, HAMILTON 80 observes a broad enhancement at 1939 ± 2 MeV, with a width of 22 ± 6 MeV. The magnitude of the enhancement above background is 3.0 ± 0.7 mb, compared with the 18^{+6}_{-3} mb found by CARROLL 74. The dominant coupling seems to be to the annihilation channels.

No significant signal is observed for a narrow S(1935) in backward antiproton-proton elastic scattering (GARNJOST 79), nor in the charge-exchange cross section (GARNJOST 75, CHALOUPKA 76, HAMILTON 80).

No evidence for the S(1935) has been reported in production experiments except by DAUM 79, who see a narrow enhancement at 1940 MeV in an inclusive $\bar{p}p$ mass spectrum from proton-proton interactions at 93 GeV/c. A $\bar{p}p$ enhancement at the mass of the S(1935) and having a narrow width is also observed in photoproduction (RICHARD 79).

The absence of the S(1935) in the most recent antiproton-deuterium total cross-section measurements (ALBERI 79, HAMILTON 80) favors I=0 for a resonance with a width smaller than 20 MeV. The DEFOIX 80 data suggest that a large enhancement (width of the order of 80 MeV) at 1950 MeV might be present in the I=1 five-pion annihilation channel.

The existence of a narrow S(1935) resonance is still open to conjecture, but it may be the case that two resonances, with I=0 and I=1, are present in the 1935-1950 MeV mass region, both having a relatively large coupling to the antiproton-proton channel. Spins of 2 to 4 are compatible with all experimental data, although HAMILTON 80 favors spin 0 or 1.

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                31  S MASS (MEV)

M        S CHANNEL NBAR N
M   C      (1940.)     (8.)                CLINE      70 HBC   0  .25-.74 PBAR P    2/72
M   B      (1968.)                         BENVENUTI  71 HBC   0  .1 - .8 PBAR P    2/72
M  S        1932.       2.                 CARROLL    74 CNTR     S CHAN.PBAR P,D  12/75
M   C      (1942.)     (5.)                D-ANDLAU   75 HBC   0 .175-.750 PBAR P  12/75
M   Z      (1934.4)    (2.6)      (1.4)    KALOGERO   75 DBC   - PBAR N ANNIH      12/75
M   Z    NOT SEEN BY ALBERI 79 WITH COMPARABLE STATISTICS.
M  S        1935.9      1.0                CHALOUPKA  76 HBC   0 PBAR P TOT,ELAS   12/75
M           1939.0      3.0                BRUCKNER   77 SPEC  0 .4-.85 PBAR P      7/77
M           1935.5      1.0                SAKAMOTO   79 HBC   0 .37-.73 PB P      12/79*
M   A      (1949.)    (10.)                DEFOIX     80 HBC   0 PBAR P,5PI         1/80*
M    M      1939.0      2.0                HAMILTON   80 CNTR  0 S CHAN,PBAR P     12/79*
M
M        PRODUCTION EXPERIMENTS
M        36(1940.0)    (1.0)               DAUM       79 CNTR  0 93 P P,PB P + X  12/79*
M           . . . . . . . . .
M   AVG     1935.80     0.84    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
M   STUDENT1935.82      0.70    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                      (SEE IDEOGRAM BELOW )

M   A    FROM ENERGY DEPENDENCE OF 5PI CROSS-SECTION.IG=1- FROM OBSERVATION
M   A    OF OMEGA RHO DECAY. P=+ AND J>1. A2 PI PI ALSO SEEN.
M   B    SEEN AS A BUMP IN THE PBAR P - KS KL  CROSS SECTION WITH JPC=1--.
M        NOT SEEN BY CARSON 72 WITH EQUAL STATISTICS.
M   C    FROM ENERGY DEPENDENCE OF FAR BACKWARD ELASTIC SCATTERING.
M        SOME INDICATION OF ADDITIONAL STRUCTURE.
M    M   I=0 FAVOURED,J=0 OR 1,SEEN IN TOTAL PBAR P TOTAL CROSS-SECTION,
M    M   PRIMARLY FROM ANNIH. REACTIONS;NOT SEEN IN PBAR D TOTAL AND
M    M   ANNIH. CROSS SECTIONS.
M   N    SEEN IN 3 CHARGED MODE. NOT SEEN BY BOWEN 73 WITH 6X STATISTICS.
M   S    NARROW BUMP SEEN IN TOTAL PBAR P,D CROSS-SECTIONS.ISOSPIN UNCERTAIN
M        NOT SEEN IN PBAR P CEX BY GARNJOST 75,CHALOUPKA 76. INTEGRATED
M        CROSS-SECTION 3X LARGER THAN BRUCKNER 77.
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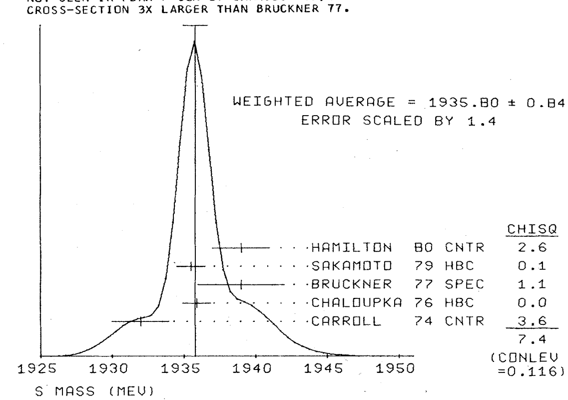

Data Card Listings

For notation, see key at front of Listings.


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                      31   S WIDTH (MEV)

W        S CHANNEL  NBAR N
W   C        (49.)      (9.)             CLINE      70 HBC   0  .25-.74 PBAR P   2/72
W   B        (35.)                       BENVENUTI 71 HBC   0  .1 - .8 PBAR P   2/72
W  S          9.         4.        3.    CARRCLL    74 CNTR    S CHAN.PBAR P,D  12/75
W   C        (57.5)     (5.)             D-ANDLAU   75 HBC   0 .175-.750 PBAR P 12/75
W   Z        (11.)      (11.)     (4.)   KALOGERO   75 DBC   - PBAR N ANNIH     12/75
W   Z    NOT SEEN BY ALBERI 79 WITH COMPARABLE STATISTICS.
W  S          8.8        4.3       3.2   CHALOUPKA 76 HBC   0 PBAR P TOT,ELAS  12/75
W            (4.0)   OR LESS             BRUCKNER   77 SPEC  0 .4-.85 PBAR P     7/77
W             2.8        1.4             SAKAMOTO   79 HBC   0 .37-.73 PB P     12/79*
W   A        (80.)      (20.)            DEFOIX     80 HBC   0 PBAR P,5PI        1/80*
W    M        22.0       6.0             HAMILTON   80 CNTR  0 S CHAN,PBAR P    12/79*
W
W        PRODUCTION EXPERIMENTS
W            (6.0)   APPROX.             DAUM       79 CNTR    93 P P,PB P + X  12/79*
W             . . . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 2.1)

W    SEE FOOTNOTES UNDER S MASS ABOVE

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                      31   S PARTIAL DECAY MODES

                                                                   DECAY MASSES
P1       S INTO PBAR P                                           938+ 938

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REFERENCES FOR S(1935)


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CLINE     68 PRL 21 1268         +ENGLISH,REEDER,TERRELL,TWITTY  (WISCONSIN)
CLINE     70  PREPRINT           D.CLINE,J.ENGLISH,D.D.REEDER         (WISC)J
   ALSO   70  KIEV CONF.         ASTIER RAPPORTEUR TALK
BENVENUT 71 PRL 27 283          BENVENUTI,CLINE,RUTZ,REEDER,SCHERER  (WISC)
PINSKI    71 PRL 27 1548         STEPHEN S. PINSKY              (UTAH+ARGONNE)
BIZZARRI 72 PR D 6 160          +GUIDONI,MARZANO,CASTELLI,+      (ROMA+TRST)
BOWEN 1   72 PRL 29 890          +EARLES,FAISSLER,BLIEDEN,+       (NEAS+STON)

BOWEN     73 PRL 30 332          +EARLES,FAISSLER,BLIEDEN,+       (NEAS+STON)
BURNS     73 PR D 8 1286         +CONDON,DONAHUE,MANDELKERN,PRICE,+     (UCI)
KIENZLE   73 PR D 7 3520         W.KIENZLE                             (CERN)

BURNS     74 NC 20A 463          +CONDON,MANDELKERN,PRICE,SCHULTZ       (UCI)
CARROLL   74 PRL 32 247          +CHIANG,KYCIA,LI,MAZUR,MICHAEL,+       (BNL)

ABASHIAN 75 PRL 34 691          +BEAMER,BROSS,EISENSTEIN,+     (ILL+ANL+ISU)
D-ANDLAU 75 PL 58B 223          +COHEN-GANOUNA,LALOUM,LUTZ,PETRI(CDEF+PISA)  JP
DEFOIX    75 PALERMO  CONF.      B.FRENCH, RAPPORTEURS TALK            (CDEF)
DONNACHI 75 NC 26 A 317         A.DONNACHIE,P.R.THOMAS          (MANCHESTER)
GARNJOST 75 PRL 35 1685         +KENNEY,POLLARD,ROSS,TRIPP,+      (LBL+MHCO)
KALOGERO 75 PRL 34 1047         KALOGEROPOULOS,TZANAKOS               (SYRA)
WEINGART 75 PRL 34 1201         WEINGARTEN,CKUBO                      (ROCH)

ABASHIAN 76 PR D 13 5           +WATSON,GELFAND,BUTTRAM,+(ILL+ANL+CHIC+ISU)
DEFOIX    76 STOCK.SYMP.NBAR-N +LADRON DE GUEVARA,ANGELINI,+   (CDEF+PISA)
DOVER     76 PL 62 B 293         +KAHANA                                (BNL)
CHALOUPK 76 PL 61 B 487         CHALOUPKA,+ (CERN+LIVP+MONS+PADO+ROMA+TRST)

BENKHEIR 77 PL B 68 483         BENKHEIRI,BOUCROT,+   (CERN+CDEF+EPOL+LALO)
BRUCKNER 77 PL 67 B 222         +GRANZ,INGHAM,KILIAN,LYNEN+(MPIH+HEID+CERN)
MONTANET 77  BOSTON CONF.       L.MONTANET                            (CERN)
ROSSI     77 PL 70 B 255         G.C.ROSSI,G.VENEZIANO                 (CERN)

CARTER    78 NP B 132 176        A.A.CARTER                            (LCQM)  JP
CUTTS     78 PR D 17 16          +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)
PENNINGT 78 NP B 137 77         M.R. PENNINGTON                       (CERN)

ALBERI    79 PL 83 B 247         +ALVEAR,CASTELLI,POROPAT+   (TRST+CERN+RIO)
ALSTON-G 79 PRL 43 1901         ALSTON-GARNJOST,HAMILTON+     (LBL+MTHO+BNL)
CARROLL   79 PR D 19 1950        +CHIANG,KYCIA,LI,LITTENBERG,+    (BNL+ROCH)
DAUM      79  CERN/EP 79-157     +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
DELCOURT 79 PL B 86 395         +DERADO,BERTRAND,BISELLO,BIZOT,BUON,+(LALO)
GIBBARD   79 PRL 42 1593         +AHRENS,BERKELMAN,CASSEL,DAY,HARDING+(CCRN)
KLUYVER   79 ZPHY C 2 351        J.C. KLUYVER                          (AMST)
RICHARD   79  LAL-79/35          F. RICHARD                            (LALO)
SAKAMOTO 79 NP B 158 410        +HASHIMOTO,SAI,YAMAMOTO+              (TCKY)

DEFOIX    80 NP B 162 12         +DOBRZYNSKI,ANGELINI,BIGI,+      (CDEF+PISA)
    ALSO  80 NP B 162 41         ESPIGAT,DEFOIX,DOBRZYNSKI,LALOUM+(CDF+PISA)
HAMILTON 80 PRL                 +PUN,TRIPP,LAZARUS,NICHCLSON (LBL+BNL+MTHO)
KAMAE     80 PRL                 +AIHARA,CHIBA,FUJII,IWASAKI,+    (TOKY,HIRO)
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h(2040)

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16   H(2040,JPG=4++) I=0

APEL 75 AND BLUM 75 ESTABLISH JP AS 4+ AND I=0.
ADDITIONAL EVIDENCE FOR THE H MESON IS REPORTED
IN WAGNER 74.

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                      16   H MASS (MEV)

M       700 2030.       30.              APEL       75 CNTR    40.  PI-P,N 2PIO 11/75
M           2050.       25.              BLUM       75 ASPK    18.4 PI-P,N K+K- 11/75
M           1935.0      13.0             CORDEN     79 OMEG    12-15PI-P, N 2PI 12/79*
M           1988.0       7.0             EVANGELIS 79 OMEG    10. PI-P,K+ K- N 12/79*
M     M    (2040.0)    (10.0)            ROZANSKA   80 SPRK    18.PI-P,P PB N   12/79*
M     M  I=0,JP=4+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE           12/78*
M             . . . . . . . . .
M    AVG      1982.2     16.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.8)
M    STUDENT1986.7       7.5      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                               (SEE IDEOGRAM BELOW )
```

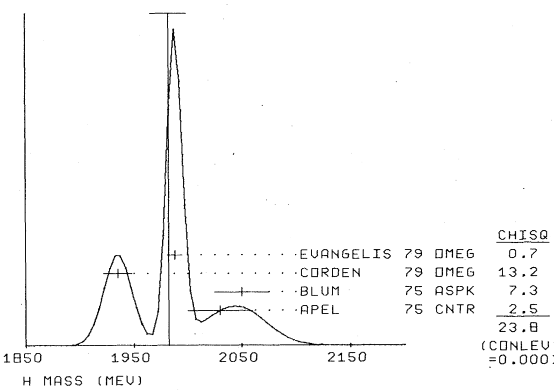


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                      16   H WIDTH (MEV)

W       700  180.       60.              APEL       75 CNTR    40.  PI-P,N 2PIO 11/75
W            225.      120.      70.     BLUM       75 ASPK    18.4 PI-P,N K+K- 11/75
W            263.0      57.0             CORDEN     79 OMEG    12-15PI-P, N 2PI 12/79*
W            100.0      28.0             EVANGELIS 79 OMEG    10. PI-P,K+ K- N 12/79*
W     M     (140.0)    (15.0)            ROZANSKA   80 SPRK    18.PI-P,P PB N   12/79*
W     M  I=0,JP=4+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE           12/78*
W             . . . . . . . . .
W    AVG      143.7      36.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
W    STUDENT 142.7       31.1     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                               (SEE IDEOGRAM BELOW )
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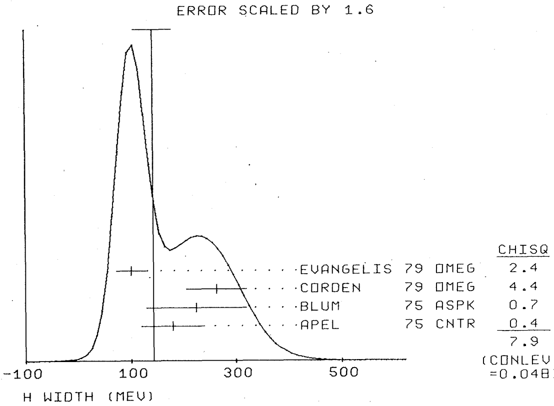


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                      16   H PARTIAL DECAY MODES

                                                                   DECAY MASSES
P1       H INTO PI PI                                            139+ 139
P2       H INTO K KBAR                                           497+ 497

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                      16   H BRANCHING RATIOS

R1       H INTO (PI PI)/TOTAL                                 (P1)
R1              0.17       0.02          CORDEN     79 OMEG    12-15PI-P, N 2PI 12/79*

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REFERENCES FOR H(2040)


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WAGNER    74  LONDON CONF.       F. WAGNER, RAPPORTEURS TALK           (MPIM)
APEL      75 PL 57B 398          +AUGENSTEIN+     (KARL+PISA+SERP+WIEN+CERN)  JP
BLUM      75 PL 57B 403          +CHABAUD,DIETL,GARELICK,GRAYER+ (CERN+MPIM)  JP

CORDEN    79 NP B 157 250        +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LCWC)  JP
EVANGELI 79 NP B 154 381        + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)
ROZANSKA 80 NP B 162 505        +BLUM,DIETL,GRAYER,LORENZ+       (MPIM+CERN)
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Mesons

T AND U REGIONS, T0(2150), T1(2190)

Data Card Listings

For notation, see key at front of Listings.

Note on T and U Regions

The observation of broad enhancements at 2190 and 2350 MeV comes from $\bar{p}p$ total cross-section measurements (ABRAMS 67), $\bar{p}p$ annihilation measurements (ALSPECTOR 73), $\bar{p}p$ elastic cross-section measurements (COUPLAND 77), and from $\bar{p}p$ charge-exchange cross-section measurements (CUTTS 78).

The comparison of $\bar{p}p$ and $\bar{p}d$ total cross sections (ABRAMS 67) suggests $I = 1$ for the 2190 MeV enhancement, called T1, whereas $I = 0$ and $I = 1$ are both present in the 2400 MeV mass region, which we call U0 and U1, respectively.

Partial-wave analysis of $\bar{p}p$ annihilation into $\pi^+\pi^-$ (CARTER 77) and into $\pi^0\pi^0$ (DULUDE 78) have shown that resonances are formed in the $\pi\pi$ annihilation channels in the 2100-2500 MeV mass region (no statistically significant data are available outside this mass region). The analysis of MARTIN 78 which combines the $\pi^+\pi^-$ data of EISENHANDLER 75 and CARTER 77 and the $\pi^0\pi^0$ data of DULUDE 78 finds evidence for a $J^P = 2^+$, $I^G = 0^+$ resonance near 2150 MeV, called T0, and for a $J^P = 5^-$, $I^G = 1^+$ resonance near 2450 MeV, which may be too high in mass to be associated to the U1 bump observed in the $\bar{p}p$ total cross section. The $\pi\pi$ partial-wave analysis gives ambiguous results on the $I = 1$ component in the T region, favoring however, $J^P = 1^-$, and on both $I = 0$ and $I = 1$ components in the U (2350-2450 MeV) mass region, where resonances with spin three and four may be present.

Model-dependent partial-wave analyses of the $\bar{p}p$ system produced with incident pion beams and relying on one-pion-exchange mechanisms suggest the presence of resonances with spin 2, 3, 4, and 5 in the 2100 to 2500 MeV mass region (EVANGELISTA 79, ROZANSKA 79).

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T0(2150) →

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42  T0(2150,JPG=2++) I=0

THIS ENTRY CONTAINS THE I=0 STRUCTURES FOUND BY
AMPLITUDE ANALYSES OF PBAR P INTO PI PI OR KB K AND
BY MOMENTS ANALYSES OF THE PBAR P SYSTEM
PERIPHERALLY PRODUCED BY INCIDENT PIONS.
WE LIST ALSO THE BUMPS FOUND IN S-CHANNEL
NBAR N OF UNDEFFINED ISOSPIN.
SEE ALSO S,T,U MINI-REVIEWS.
OMITTED FROM TABLE.

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                42  T0(2150) MASS (MEV)

M       S CHANNEL NBAR N
M    I     2193.      2.            ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M  E I     2155.0     15.0          COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
M  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M    I    (2190.0)  APPROX.         CUTTS      78 CNTR   .97-3. PB P,NB N 12/78*
M    I  ISOSPINS 0 AND 1 NOT SEPARATED
M       PBAR P INTO PI PI OR KB K
M    L    (2150.0)  APPROX.         DULUDE2   78 OSPK    1.-2.PB P,PIOPIO 12/78*
M    L  IG=0+,JP=2+ FROM PARTIAL WAVE AMPLITUDE ANALYSIS
M    P    (2150.0)  APPROX.         MARTIN     79 RVUE                    12/79*
M    P  I=0,JP=2+ FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO
M    P  WITH THE PARTIAL-WAVE EXPANSION TRUNCATED IN J.
M
M       PBAR P PRODUCTION EXPERIMENTS
M    M     2180.0     10.0          ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79*
M    M  I=0,JP=2+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE.
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

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                42  T0(2150) WIDTH (MEV)

W       S CHANNEL NBAR N
W    I      98.       8.            ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
W  E I     135.0     75.0           COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P
W  E    FROM A FIT TO THE TOTAL ELASTIC CRCSS SECTION.
W    I  ISOSPINS 0 AND 1 NOT SEPARATED
W
W       PBAR P INTO PI PI OR KB K
W    L    (250.0)  APPROX.          DULUDE2   78 OSPK    1.-2.PB P,PIOPIO 12/78*
W    L  IG=0+,JP=2+ FROM PARTIAL WAVE AMPLITUDE ANALYSIS
W    P    (250.0)  APPROX.          MARTIN     79 RVUE                    12/79*
W    P  I=0,JP=2+ FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO
W    P  WITH THE PARTIAL-WAVE EXPANSION TRUNCATED IN J.
W
W       PBAR P PRODUCTION EXPERIMENTS
W    M     270.0     10.0           ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79*
W    M  I=0,JP=2+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE
W          . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR =13.4)

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REFERENCES FOR T0(2150)


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ALSPECTO 73 PRL 30 511          ALSPECTOR,COHEN,CVIJANOVICH,+    (RUTG+UPNJ)

COUPLAND 77 PL 71 B 460         +EISENHANDLER,GIBSON,ASTBURY,+   (LOQM+RHEL)

CUTTS    78 PR D 17 16          +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)
DULUDE1  78 PL 79 B 329         +LANOU,MASSIMO,PEASLEE+        (BROW+MIT+BARI)
DULUDE2  78 PL 79 B 335         +LANOU,MASSIMO,PEASLEE+        (BROW+MIT+BARI)

BOWCOCK  79  PREP. BIRMINGH.    J.E.BOWCOCK,D.C.HODGSON                 (BIRM)
MARTIN   79 PL 86 B 93          A.D. MARTIN,M.R. PENNINGTON             (DURH)
  ALSO   80  DURHAM PREPRINT    A.D. MARTIN,M.R. PENNINGTON             (DURH)
ROZANSKA 80 NP B 162 505        +BLUM,DIETL,GRAYER,LORENZ+         (MPIM+CERN)
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T1(2190) →

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32  T1(2190,JPG=    ) I=1.

THIS ENTRY CONTAINS THE I=1 BUMP OBSERVED IN S-CHANNEL
NBAR N AND THE STRUCTURES FOUND BY AMPLITUDE
ANALYSES OF PBAR P INTO PI PI OR KB K AND
BY THE MOMENTS ANALYSES OF THE PBAR P SYSTEM
PERIPHERALLY PRODUCED BY INCIDENT PIONS.
SEE ALSO S,T,U MINI-REVIEWS.
OMITTED FROM TABLE.

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                32  T1(2190) MASS (MEV)

M       S CHANNEL NBAR N
M  B       2190.      10.           ABRAMS     70 CNTR   S CHANNEL PBAR N  1/73
M  B    SEEN AS BUMP IN I=1 STATE. SEE ALSO COOPER 68.
M  B    PEASLEE 75 CONFIRM PBAR P RESULTS OF ABRAMS 7C,NO NARROW STRUCTURE
M    I     2193.      2.            ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M  E I     2155.0     15.0          COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
M  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M    I    (2190.0)  APPROX.         CUTTS      78 CNTR   .97-3. PB P,NB N 12/78*
M    I  ISOSPINS 0 AND 1 NOT SEPARATED
M
M       PBAR P INTO PI PI OR KB K
M  J      (2150.0)                  CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
M  J    I=1,JP=3- FROM AMPLITUDE ANALYSIS.
M    K    (2140.0)  APPROX.         CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78*
M    K  I=0,1.JP=3- FROM BARRELET ZERO'S ANALYSIS.
M
M       PBAR P PRODUCTION EXPERIMENTS
M    R    (2110.0)  APPROX.         EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79*
M    R  I=1,JP=3- FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
M    R  SOLUTICN A.
M    N     2110.0     10.0          ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79*
M    N  I=1,JP=3- FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 5.8)

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                32  T1(2190) WIDTH (MEV)

W       S CHANNEL NBAR N
W  B       (85.)                    ABRAMS     67 CNTR   S CHANNEL PBAR N  7/67
W  B    SEE NOTE B ABOVE.
W    I      98.       8.            ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
W  E I     135.0     75.0           COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
W  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W    I  ISOSPINS 0 AND 1 NOT SEPARATED
W
W       PBAR P INTO PI PI OR KB K
W  J      (200.0)                   CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
W  J    I=1,JP=3- FRCM AMPLITUDE ANALYSIS.
W    K    (150.0)  APPROX.          CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78*
W    K  I=0,1.JP=3- FROM BARRELET ZERO'S ANALYSIS.
W
W       PBAR P PRODUCTION EXPERIMENTS
W    R    (330.0)  APPROX.          EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79*
W    R  I=1,JP=3- FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
W    R  SOLUTION A.
W    N     190.0     10.0           ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79*
W    N  I=1,JP=3- FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE
W          . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 7.2)

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Data Card Listings

For notation, see key at front of Listings.

Mesons

T1(2190), X(2200), U0(2350)

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                    32  SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLECN

CS A        (5.5)                       ABRAMS    70 CNTR    S CHANNEL PBAR N  1/71
CS A     FOR I=1 NBAR N
CS            2.3       0.13      0.08  ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74

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                    32  T1(2190) PARTIAL DECAY MODES

                                                               DECAY MASSES
P1      T INTO PBAR P                                        938+ 938
P2      T INTO PI PI                                         139+ 139

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                              REFERENCES FOR T1(2190)

ABRAMS    67 PRL 18 1209      +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)
COOPER    68 PRL 20 1059      +HYMAN,MANNER,MUSGRAVE,VOYVODIC        (ANL)
BRICMAN   69 PL 29 B 451      +FERRO-LUZZI,BIZARD,+       (CERN+CAEN+SACL)
ABRAMS    70 PR D 1 1917      +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)

BACCN     71 NP B 32 66       +BUTTERWORTH,MILLER,PHELAN,+     (RHEL+LIVP)
FIELDS    71 PRL 27 1749      +COOPER,RHINES,ALLISCN             (ANL+OXF)
YOH       71 PRL 26 922       +BARISH,CAROLL,LOBKOVICZ+     (CIT+BNL+RCCH)

ALEXANDE  72 NP B 45 29       ALEXANDER,BAR-NIR,BEVARY,DAGAN,+      (TELA)
BUGG      72 PR D 6 3047      +CONDO,HART,COHN,ENDORF,+  (TENN+ORNL+CINC)
CLAYTON   72 NP B 47 81       +MASON,MUIRHEAD,RIGOPOULOS,+     (LIVP+PATR)
DCNALD    72 PL 40 B 586      +GALLETLY,EDWARDS,DE BILLY,+     (LIVP+LPNP)

ALSPECTO  73 PRL 30 511       ALSPECTOR,COHEN,CVIJANOVICH,+    (RUTG+UPNJ)
BACCN     73 PR D 7 577       +BUTTERWORTH,                    (RHEL+LIVP)
BETTINI   73 NC 15 A 563      +GARNJOST,BIGI,+        (PADO+LBL+PISA+TORI)
BOWEN     73 PRL 30 332       +EARLES,FAISSLER,BLIEDEN,+       (NEAS+STON)
MING MA   73 NP B 51 77       +EASTMAN,OH,PARKER,SMITH,SPRAFKA       (MSU)
NICHOLSO  73 PR D 7 2572      NICHOLSON,DELORME,CARROLL,+  (CIT+ROCH+BNL)

BERTANZA  74 NC 23A 209       +BIGI,CASALI,LARICCIA,+     (PISA+PADO+TORI)
HYAMS     74 NP B 73 202      +JONES,WEILHAMMER,BLUM,+         (CERN+MPIM)

DCNNACHI  75 NC 26 A 317      A.DONNACHIE,P.R.THOMAS          (MANCHESTER)
EISENHAN  75 NP B 96 109      EISENHANDLER,GIBSON,+ (LOQM+LIVP+DARE+RHEL)
HANDLER   75 NP B101 35       +JACQUES,JONES,PANDOULAS,+ (RUTG+STEV+ALBA)
HUESMAN   75 NC 25A  91       +GARNJOST,ROSS,+        (LBL+PADO+PISA+TORI)
PEASLEE   75 PL 57B 189       +DEMARZO,GUERRIERO,+    (CANB+BARI+BROW+MIT)

GAY       76 NC 31 A 593      +JEANNERET,BOGDANSKI,+(NEUC+LAUS+LIVP+LPNP)
ZEMANY    76 NP B 103 537     +MING MA,MOUNTZ,SMITH                  (MSU)

CARTER 1  77 PL 67 B 117      +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
CARTER 2  77 PL 67 B 122      A.A.CARTER                            (LCQM)  JP
CARTER 3  77 NP B 127 202     +COUPLAND,ATKINSON,ARNISON+(LOQM+DARE+RHEL)
COUPLAND  77 PL 71 B 460      +EISENHANDLER,GIBSCN,ASTBURY,+   (LCQM+RHEL)
JONES     77 NP B 119 476     M.D.JONES,R.J.PLANO                   (RUTG)
MCNTANET  77  BOSTCN CONF.    L.MONTANET                            (CERN)

CARTER 1  78 NP B 132 176     A.A.CARTER                            (LCQM)  JP
CARTER 2  78 NP B 141 467     A.A.CARTER                            (LCQM)
CUTTS     78 PR D 17 16       +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)
DULUDE1   78 PL 79 B 329      +LANOU,MASSIMO,PEASLEE+      (BROW+MIT+BARI)
DULUDE2   78 PL 79 B 335      +LANOU,MASSIMO,PEASLEE+      (BROW+MIT+BARI)

EVANGELI  79 NP B 153 253     + (BARI+BCNN+CERN+DARE+GLAS+LIVP+MILA+WIEN)
MARTIN    79 PL 86 B 93       A.D. MARTIN,M.R. PENNINGTON           (DURH)
   ALSO   80  DURHAM PREPRINT A.D. MARTIN,M.R. PENNINGTON           (DURH)
ROZANSKA  80 NP B 162 505     +BLUM,DIETL,GRAYER,LORENZ+       (MPIM+CERN)

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X(2200)

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44   X(2200,JPG=    ) I=

SEEN IN K+,K- MASS SPECTRUM FROM PI- P INTERACTIONS
AT 10 GEV.(EVANGELISTA 79).NEEDS CONFIRMATION.
OMITTED FROM TABLE.

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                    44   X(2200) MASS.(MEV)

M        2210.0      79.0      21.0   EVANGELIS 79 OMEG    10. PI-P,K+ K- N 12/79*

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                    44   X(2200) WIDTH.(MEV)

W        (203.0)  APPROX.             EVANGELIS 79 OMEG    10. PI-P,K+ K- N 12/79*

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                    44   X(2200) PARTIAL DECAY MODES

                                                               DECAY MASSES
P1      X(2200) INTO PI+ PI-                                  139+ 139
P2      X(2200) INTO K+ K-                                    493+ 493

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                    44   X(2200) BRANCHING RATIOS

R1      X(2200) INTO ( K+ K- )/TOTAL                     (P2)
R1          SEEN                        EVANGELI  79 OMEG  0 10 PI- P, K+ K-   12/79*

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                              REFERENCES FOR X(2200)

EVANGELI 79 NP B 154 381     + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)

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U0(2350)

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41   U0(2350,JPG=    ) I=0

THIS ENTRY CONTAINS THE BROAD I=0 BUMP OBSERVED
IN THE S-CHANNEL NBAR N AND THE STRUCTURE FOUND
BY AMPLITUDE ANALYSES OF PBAR P INTO PI PI OR KB K
AND BY AMPLITUDE ANALYSES OF PBAR P SYSTEMS
PERIPHERALLY PRODUCED BY INCIDENT PIONS.
SEE ALSO S,T,U MINI-REVIEWS.
OMITTED FRCM TABLE.

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                    41   U0(2350) MASS

M         2375.        10.            ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71
M   I    (2359.)      (2.)            ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M  EI    (2345)     (15.0)            COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
M  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M   I    (2380.0)  APPROX.            CUTTS     78 CNTR    .97-3. PB P,NB N 12/78*
M   I   ISOSPINS 0 AND 1 NOT SEPARATED
M
M       PBAR P INTO PI PI OR KB K
M  J      (2310.0)                    CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
M  J    I=0,JP=4+ FROM AMPLITUDE ANALYSIS.
M    K    (2340.0)  APPROX.           CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78*
M    K  I=0,JP=4+ FRCM BARRELET ZERO'S ANALYSIS
M
M       PBAR P PRODUCTION EXPERIMENTS
M    R    (2260.0)  APPROX.           EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79*
M    R  I=0,JP=4+ FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
M    R  SOLUTICN A.
M    M     2380.0      10.0           ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79*
M    M  I=0,JP=4+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                    41   U0(2350) WIDTH

W         (190.)                      ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71
W   I     (165.)     (18.)      (8.)  ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
W  EI     (135.0)  (150.0)    (65.0)  COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
W  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W   I   ISOSPINS 0 AND 1 NOT SEPARATED
W
W       PBAR P INTO PI PI OR KB K
W  J    I=0,JP=4+ FROM AMPLITUDE ANALYSIS.
W  J      (210.0)                     CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
W    K    (150.0)  APPROX.            CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78*
W    K  I=0,JP=4+ FRCM BARRELET ZERO'S ANALYSIS
W
W       PBAR P PRODUCTION EXPERIMENTS
W    R    (440.0)  APPROX.            EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79*
W    R  I=0,JP=4+ FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
W    R  SOLUTICN A.
W    M     380.0       20.0           ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79*
W    M  I=0,JP=4+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE

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                    41   U0(2350) SIGMA (MB) FOR FORMATION EXPERIMENTS

CS          (2.5)                     ABRAMS    70 CNTR                      1/71
CS  I       (2.1)     (0.2)    (0.1)  ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
CS  I   ISOSPINS 0 AND 1 NOT SEPARATED

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                    41   U0 PARTIAL DECAY MCDES

                                                               DECAY MASSES
P1      U INTO PBAR P                                        938+ 938
P2      U INTO PI PI                                         139+ 139

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                              REFERENCES FOR U0(2350)

BRICMAN   69 PL 29 B 451      +FERRO-LUZZI,BIZARD,+       (CERN+CAEN+SACL)
ABRAMS    70 PR D 1 1917      +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)
EASTMAN   72 NP B 51 29       +MING MA,OH,PARKER,SMITH,SPRAFKA       (MSU)
MING MA   72 NP B 51 77       +EASTMAN,OH,PARKER,SMITH,SPRAFKA       (MSU)
ALSPECTO  73 PRL 30 511       ALSPECTOR,CCHEN,CVIJANOVICH,+    (RUTG+UPNJ)
NICHOLSO  73 PR D 7 2572      NICHOLSON,DELORME,CARROLL,+  (CIT+ROCH+BNL)

HYAMS     74 NP B 73 202      +JONES,WEILHAMMER,BLUM,+         (CERN+MPIM)
MING MA   74 NP B68 214       +MOUNTZ,ZEMANY,SMITH                  (MICH)

DCNNACHI  75 NC 26 A 317      A.DONNACHIE,P.R.THOMAS          (MANCHESTER)
EISENHAN  75 NP B 96 109      EISENHANDLER,GIBSON,+ (LOQM+LIVP+DARE+RHEL)

CARTER 1  77 PL 67 B 117      +COUPLAND,EISENHANDLER,ASTBURY,+(LCQM+RHEL)  JP
CARTER 2  77 PL 67 B 122      A.A.CARTER                            (LCQM)  JP
CARTER 3  77 NP B 127 202     +COUPLAND,ATKINSON,ARNISON+(LOQM+DARE+RHEL)
COUPLAND  77 PL 71 B 460      +EISENHANDLER,GIBSON,ASTBURY,+   (LOQM+RHEL)
MONTANET  77  BOSTON CONF.    L.MONTANET                            (CERN)

CARTER 1  78 NP B 132 176     A.A.CARTER                            (LOQM)  JP
CARTER 2  78 NP B 141 467     A.A.CARTER                            (LCQM)
CUTTS     78 PR D 17 16       +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)
DULUDE1   78 PL 79 B 329      +LANOU,MASSIMO,PEASLEE+      (BROW+MIT+BARI)
CULUDE2   78 PL 79 B 335      +LANOU,MASSIMO,PEASLEE+      (BROW+MIT+BARI)

BOWCOCK   79  PREP. BIRMINGH. J.E.BOWCOCK,D.C.HODGSON               (BIRM)
EVANGELI  79 NP B 153 253     + (BARI+BCNN+CERN+DARE+GLAS+LIVP+MILA+WIEN)
MARTIN    79 PL 86 B 93       A.D. MARTIN,M.R. PENNINGTON           (DURH)
   ALSO   80  DURHAM PREPRINT A.D. MARTIN,M.R. PENNINGTON           (DURH)
ROZANSKA  80 NP B 162 505     +BLUM,DIETL,GRAYER,LORENZ+       (MPIM+CERN)

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Mesons
U1(2400), $\bar{N}N$(1400–3600)

Data Card Listings
For notation, see key at front of Listings.

U1(2400)

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33  U1(2400,JPG=    ) I=1

THIS ENTRY CONTAINS THE BROAD I=1 BUMP OBSERVED
IN THE S-CHANNEL NEAR N AND THE STRUCTURE FOUND
BY AMPLITUDE ANALYSES OF PBAR P INTO PI PI OR KB K
AND BY AMPLITUDE ANALYSES OF PBAR P SYSTEMS
PERIPHERALLY PRODUCED BY INCIDENT PIONS.
SEE ALSO S,T,U MINI-REVIEWS.
OMITTED FROM TABLE.
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                    33  U1(2400 ) MASS (MEV)

M        S CHANNEL NBAR N
M  A       2350.      10.             ABRAMS    70 CNTR    S CHANNEL NBAR N  1/73
M  A     FOR I=1 NBAR N
M   N      (2360.0)   (25.0)          OH         70 HDBC  -OPBAR(P,N),K*K2PI  1/73
M   N    NO EVIDENCE FOR THIS BUMP SEEN IN THE PBAR P DATA OF CHAPMAN 71
M   N    NARROW STATE NOT CONFIRMED BY OH 73 WITH MORE DATA.
M   I      (2359.)    (2.)            ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M  EI      (2345.0)   (15.0)          COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
M  E     FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M   I      (2380.0)  APPROX.          CUTTS     78 CNTR    .97-3. PB P,NB N 12/78*
M   I    ISOSPINS 0 AND 1 NOT SEPARATED
M
M        PBAR P INTO PI PI OR KB K
M   J      (2480.0)                   CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
M   J    I=1,JP=5- FROM AMPLITUDE ANALYSIS.
M    K     (2500.0)  APPROX.          CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78*
M    K   I=0,1.JP=5- FROM BARRELET ZERO'S ANALYSIS.
M    P     (2450.0)  APPROX.          MARTIN    79 RVUE                      12/79*
M    P   I=1,JP=5- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PI0 PI0
M    P   WITH THE PARTIAL-WAVE EXPANSION TRUNCATED IN J.
M    R     (2350.0)  APPROX.          MARTIN    80 RVUE                       1/80*
M    R   I=1,JP=3- AND 5- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND
M    R   PI0 PI0 WITH THE PARTIAL-WAVE EXPANSION TRUNCATED IN L.
M
M        PBAR P PRODUCTION EXPERIMENTS
M    M     2450.0     10.0            ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79*
M    M   I=1,JP=5- FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE
M           . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 7.1)
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                    33  U1(2400 ) WIDTH (MEV)

W        S CHANNEL NBAR N
W          (140.)                     ABRAMS    67 CNTR    S CHANNEL PBAR N  1/73
W  N         (60.0)  OR LESS          OH         70 HDBC  -OPBAR(P,N),K*K2PI 11/71
W  N     NO EVIDENCE FOR THIS BUMP SEEN IN THE PBAR P DATA OF CHAPMAN 71
W   N    NARROW STATE NOT CONFIRMED BY OH 73 WITH MORE DATA.
W   I      (165.)    (18.)     (8.)   ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
W  EI      (135.0)   (150.0)   (65.0) COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
W  E     FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W   I    ISOSPINS 0 AND 1 NOT SEPARATED
W
W        PBAR P INTO PI PI OR KB K
W  J       (210.0)                    CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
W  J     I=1,JP=5- FROM AMPLITUDE ANALYSIS.
W    K     (150.0)  APPROX.           CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78*
W    K   I=0,1.JP=5- FROM BARRELET ZERO'S ANALYSIS.
W    P     (300.0)  APPROX.           MARTIN    79 RVUE                      12/79*
W    P   I=1,JP=5- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PI0 PI0
W    P   WITH THE PARTIAL-WAVE SERIES TRUNCATED IN J.
W    R     (200.0)  APPROX.           MARTIN    80 RVUE                       1/80*
W    R   I=1,JP=3- AND 5- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND
W    R   PI0 PI0 WITH THE PARTIAL-WAVE EXPANSION TRUNCATED IN L.
W
W        PBAR P PRODUCTION EXPERIMENTS
W    M     280.0      20.0            ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79*
W    M   I=1,JP=5- FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE
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                    33  SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON

CS  A       (3.2)                     ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71
CS  A    FOR I=1 NBAR N
CS  I      (2.1)     (0.2)     (0.1)  ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
CS  I    ISOSPINS 0 AND 1 NOT SEPARATED
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REFERENCES FOR U1(2400)


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ABRAMS    67 PRL 18 1209        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)
BRICMAN   69 PL 29 B 451        +FERRO-LUZZI,BIZARD,+          (CERN+CAEN+SACL)
CASO      69 LNC 3 707          +CONTE,BENZ,+       (GENO+DESY+HAMB+MILA+SACL)
ABRAMS    70 PR D 1 1917        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)
OH        70 PRL 24 1257        +PARKER,EASTMAN,SMITH,SPRAFKA,MA       (MSU)

CHAPMAN   71 PR D4 1275         +GREEN,LYS,MURPHY,RING,+              (MICH)
FIELDS    71 PRL 27 1749        +COOPER,RHINES,ALLISON            (ANL+CXF)
YOH       71 PRL 26 922         +BARISH,CAROLL,LOBKOVICZ+    (CIT+BNL+RCCH)

EASTMAN   72 NP B 51 29         +MING MA,OH,PARKER,SMITH,SPRAFKA       (MSU)
MING MA   72 NP B 51 77         +EASTMAN,OH,PARKER,SMITH,SPRAFKA       (MSU)

ALSPECTO  73 PRL 30 511         ALSPECTOR,COHEN,CVIJANOVICH,+   (RUTG+UPNJ)
BOWEN     73 PRL 30 332         +EARLES,FAISSLER,BLIEDEN,+      (NEAS+STON)
DONNACHI  73 LNC 7 285          A.DONNACHIE,P.R.THOMAS         (MANCHESTER)
OH        73 NP B 51 57         +EASTMAN,MING MA,PARKER,SMITH,+        (MSU)
NICHOLSO  73 PR D 7 2572        NICHOLSON,DELORME,CARROLL,+   (CIT+ROCH+BNL)

HYAMS     74 NP B 73 202        +JONES,WEILHAMMER,BLUM,+         (CERN+MPIM)
MING MA   74 NP B68 214         +MOUNTZ,ZEMANY,SMITH                  (MICH)

DONNACHI  75 NC 26 A 317        A.DONNACHIE,P.R.THOMAS         (MANCHESTER)
EISENHAN  75 NP B 96 109        EISENHANDLER,GIBSON,+ (LOQM+LIVP+DARE+RHEL)

CARTER 1  77 PL 67 B 117        +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
CARTER 2  77 PL 67 B 122        A.A.CARTER                           (LOQM)  JP
CARTER 3  77 NP B 127 202       +COUPLAND,ATKINSON,ARNISON+(LOQM+DARE+RHEL)
COUPLAND  77 PL 71 B 460        +EISENHANDLER,GIBSON,ASTBURY,+  (LOQM+RHEL)
MONTANET  77  BOSTON CONF.      L.MONTANET                           (CERN)

BALTAY    78 PR D 17 62         +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
CARTER 1  78 NP B 132 176       A.A.CARTER                           (LOQM)  JP
CARTER 2  78 NP B 141 467       A.A.CARTER                           (LOQM)
CUTTS     78 PR D 17 16         +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)

BOWCOCK   79  PREP. BIRMINGH.   J.E.BOWCOCK,D.C.HODGSON              (BIRM)
EVANGELI  79 NP B 153 253      + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)
MARTIN    79 PL 86 B 93         A.D. MARTIN,M.R. PENNINGTON          (DURH)

MARTIN    80  DURHAM PREPRINT   A.D. MARTIN,M.R. PENNINGTON          (DURH)
ROZANSKA  80 NP B 162 505       +BLUM,DIETL,GRAYER,LORENZ+      (MPIM+CERN)
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$\bar{N}$N(1400–3600)

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51  NBAR N(1400-3600)

THIS ENTRY CONTAINS VARIOUS HIGH
HIGH MASS, NON-STRANGE STRUCTURES
COUPLED TO THE BARYON-ANTIBARYON
SYSTEM AS WELL AS QUASI-NUCLEAR
BOUND STATES BELOW THRESHOLD.
SEE ALSO S,T,U  DATA CARD LISTINGS AND MINIREVIEWS.
EVIDENCE FOR STRUCTURES COUPLED TO THE ANTI-HYPERON
NUCLEON (OR C.C.) SYSTEM IS LISTED UNDER K*(2200).
OMITTED FROM TABLE.
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            51  NBAR N(1400-3600) MASSES AND WIDTHS (MEV)

M  W G     (1395.)                    PAVLOPOUL 78 CNTR    STOPPED PBARS     1/78

M  W G     (1646.)                    PAVLOPOUL 78 CNTR    STOPPED PBARS     1/78

M  W G     (1684.)                    PAVLOPOUL 78 CNTR    STOPPED PBARS     1/78

   W     OBSERVED WIDTHS CONSISTENT WITH EXPERIMENTAL RESOLUTION.
     G   THEY LOOKED FOR RADIATIVE TRANSITIONS TO BOUND P PBAR STATES,
     G   MONO-ENERGETIC GAMMA RAYS DETECTED.

M    D     (1794.5)   (1.4)           GRAY      71 DBC  -  0.PBAR D          1/72
W    D       (8.)   OR LESS  CL=.95   GRAY      71 DBC  -  0.PBAR D          1/72
     D   DECAYS TO FOUR OR MORE PIONS,I=1.

M    Z     (1897.)    (1.)            KALOGERO  75 DBC  -  PBAR N ANNIH     12/75
W    Z       (25.)    (6.)            KALOGERO  75 DBC  -  PBAR N ANNIH     12/75
     Z   NOT SEEN BY ALBERI 79 WITH COMPARABLE STATISTICS.

M  B       (1897.0)   (17.0)          ABASHIAN  76 STRC    8PI-P,P 3PI      12/77
W  B       (110.0)    (82.0)          ABASHIAN  76 STRC    8PI-P,P 3PI      12/77
   B     PRODUCED BACKWARDS.

M    R     (1920.0)  APPROX.          EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79*
W          (190.0)   APPROX.          EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79*
M    R   I=1,JP=1- FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
M    R   SOLUTION A.

M    C     (1930.)
W    C       (9.)
     C   SEE S(1935) ABOVE

M    I      1949.      10.            DEFOIX    80 HBC   0 0-1.2 PB P,5 PI  12/79*
W    I       80.       20.            DEFOIX    80 HBC   0 0-1.2 PB P,5 PI  12/79*
     I   ISOSPIN = 1 FAVOURED

M       153(2020.0)   (3.0)           BENKHEIRI 77 OMEG  0 9,12PI-P,PPPBPI- 12/77
W       153  (24.0)   (12.0)          BENKHEIRI 77 OMEG  0 9,12PI-P,PPPBPI- 12/77

M    T     (2020.0)  APPROX.          EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79*
W          (160.0)   APPROX.          EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79*
M    T   I=0,JP=2+ FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
M    T   SOLUTION A.

M    K     (2190.0)                   KALBFLEIS 69 HBC     0 S-CHANNEL PBARP  7/69
W    K      BETWEEN 20 AND 80 MEV     KALBFLEIS 69 HBC     0 S-CHANNEL PBARP  7/69
     K   SEEN IN PBAR P TO RHO0 RHO PI0. IG=1-.
     K   NOT SEEN BY BACON 73,NOR BY ZEMAN 76

M    E     (2200.)
W    E      (150.)
     E   SEE T0(2150) AND T1(2190) ABOVE

M       58(2204.0)    (5.0)           BENKHEIRI 77 OMEG -  9,12PI-P,PPPBPI-.12/77
W       58  (16.)    OR LESS          BENKHEIRI 77 OMEG -  9,12PI-P,PPPBPI- 12/77

M    A     (2207.)    (13.)           ALLES-BOR 67 HBC     0 5.7 PBAR P     12/66
W    A      (62.)     (52.)           ALLES-BOR 67 HBC     0 5.7 PBAR P     12/66
     A   ALLES-BORELLI 67 SEE NEUTRAL MODE ONLY (PI+PI-PI0)

M    S     (2141.)                    DONALD    73 HBC   0 S CHANNEL PBAR P  1/74
W    S      (14.)                     DONALD    73 HBC   0 S CHANNEL PBAR P  1/74
     S   SEEN IN FINAL STATE (OMEGA PI+ PI-)

M    U     (2360.)
W    U      (200.)

M    U     (2375.)
W    U      (200.)
     U   SEE U1(2350) AND U0(2375) ABOVE

M    M     (2450.0)   (10.0)          ROZANSKA  80 SPRK    18.PI-P,P PB N    1/80*
W    M     (280.0)    (20.0)          ROZANSKA  80 SPRK    18.PI-P,P PB N   12/80*
     M   I=1,JP=5- FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE

M  J       (2480.0)   (30.0)          CARTER    77 CNTR  0 .7-2.4PB P,PIPI  12/77
W  J       (210.0)    (25.0)          CARTER    77 CNTR  0 .7-2.4PB P,PIPI  12/77
   J     I=1,JP=5- FROM AMPLITUDE ANALYSIS OF PABAR P INTO PI PI.

M    K     (2500.0)  APPROX.          CARTER    78 CNTR  0 .7-2.4PB P,K-K+  12/78*
W    K     (150.0)   APPROX.          CARTER    78 CNTR  0 .7-2.4PB P,K-K+  12/78*
     K   I=0,1.JP=5- FROM BARRELET ZERO'S ANALYSIS.

M          (2710.0)   (20.0)          ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79*
W          (170.0)    (40.0)          ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79*

M  V       (2850.0)   (5.0)           BRAUN     76 DBC  -  5.5PBAR D,N NBP+ 12/77
W  V        (39.)    OR LESS          BRAUN     76 DBC  -  5.5PBAR D,N NBP+ 12/77
   V     DECAYS TO NBAR N AND NBAR N PI

M  W       (3080.)    (20.)           ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
W  W       (220.)     (70.)           ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
   W     DECAYS TO 3PI+ 3PI-
   W     NOT SEEN BY KALELKAR 75 WITH 1.5 TIMES MORE DATA

M  X       (3370.)    (10.)           ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
W  X       (150.)     (40.)           ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
   X     DECAYS TO 4PI+ 4PI-

M  Y       (3390.)    (20.)           ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
W  Y       (220.)     (100.)          ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
   Y     DECAYS TO 3PI+ 3PI-
   Y     NOT SEEN BY KALELKAR 75 WITH 1.5 TIMES MORE DATA
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Data Card Listings

For notation, see key at front of Listings.

Mesons

X(1900–3600), e^+e^-(1100–3100)

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M  Z      (3600.)    (20.)              ALEXANDER 72 HBC    0 6.94 PBAR P      1/73
W  Z       (140.)    (20.)              ALEXANDER 72 HBC    0 6.94 PBAR P      1/73
   Z    DECAYS TO 4PI+ 4PI-

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REFERENCES FOR NBAR N(1400-3600)


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ALLES-BO 67 NC 50 A 776         ALLES-BORELLI,FRENCH,FRISK,+     (CERN+BONN)G=-
KALBFLEI 69 PL 29 B  259        G.KALBFLEISCH,R.STRAND,V.VANDERBURG    (BNL)
ALEXANDE 70 PRL 25 63           +BAR-NIR,DAGAN,GIDAL,GRUNHAUS+   (TEL-AVIV)
KALBFLEI 70 PHILAD.CONF.P.409 G.KALBFLEISCH AND D.MILLER REVUES      (BNL)
GRAY     71 PRL 26 1491          +HAGERT,KALOGEROPOULOS               (SYRA)
ALEXANDE 72 NP B 45 29          ALEXANDER,BAR-NIR,BEVARY,DAGAN,+      (TELA)
BOGDANOV 72 PRL 28 1418         BOGDANOVA,DALKAROV,SHAPIRO            (ITEP)

DONALD   73 NP B 61 333         +EDWARDS,GIBBINS,BRIAND,DUBOC,+ (LIVP+LPNP)
GRAY     73 PRL 30 1091         +PAPADOPOULOU,KARAGEROPOULOS,+   (ATEN+SYRA)
NICHOLSO 73 PR D 7 2572         NICHOLSON,DELORME,CARROLL,+  (CIT+ROCH+BNL)

HYAMS    74 NP B 73 202         +JONES,WEILHAMMER,BLUM,+         (CERN+MPIM)

DONNACHI 75 NC 26 A 317         A.DONNACHIE,P.R.THOMAS         (MANCHESTER)
EISENHAN 75 NP B 96 109         EISENHANDLER,GIBSON,+ (LOQM+LIVP+DARE+RHEL)
KALOGERO 75 PRL 34 1047         KALOGEROPOULOS,TZANAKOS               (SYRA)

ABASHIAN 76 PR D 13 5           +WATSON,GELFAND,BUTTRAM+(ILL+ANL+CHIC+ICWA)
BRAUN    76 PL B 60 481         +BRICK,FRIDMAN,GERBER,JUILLOT,MAURER+(STRB)

BENKHEIR 77 PL B 68 483         BENKHEIRI,BOUCROT,+    (CERN+CDEF+EPOL+LALO)
CARTER   77 PL 67 B 117         +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
EVANGELI 77 PL B 72 139         EVANGELISTA+     (BARI+BONN+CERN+DARE+GLAS+)

BALTAY   78 PR D 17 52          +CAUTIS,COHEN,CSORNA,KALELKAR+  (COLU+BING)
BENKHEIR 78  LAL-78/30          BENKHEIRI,BOUCROT+     (CERN+CDEF+EPOL+LALO)
CARTER   78 NP B 141 467        A.A.CARTER                            (LOQM)
PAVLOPOU 78 PL 72 B 415         PAVLOPOULOS+      (KARL+BASL+CERN+STOH+STRB)
PENNINGT 78 NP B 137 77         M.R. PENNINGTON                       (CERN)

ALBERI   79 PL 83 B 247         +ALVEAR,CASTELLI,POROPAT+    (TRST+CERN+RIO)
ALSTON-G 79 PRL 43 1901         ALSTON-GARNJOST,HAMILTON+     (LBL+MTHO+BNL)
ARMSTRON 79 PL B 85 304         ARMSTRONG+ (AACH+BARI+BONN+CERN+GLAS+LIVP+)
BENKHEIR 79 PL 81 B 380         BENKHEIRI,BOUCROT,+    (EPOL+LALO+CDEF+CERN)
BOWCOCK  79  PREP. BIRMINGH.    J.E.BOWCOCK,D.C.HODGSON               (BIRM)
CARROLL  79 PR D 19 1950        +CHIANG,KYCIA,LI,LITTENBERG,+     (BNL+RCCH)
DELCOURT 79 PL B 86 395         +DERADO,BERTRAND,BISELLO,BIZOT,BUON,+(LALO)
EVANGELI 79 NP B 153 253        + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)
GIBBARD  79 PRL 42 1593         +AHRENS,BERKELMAN,CASSEL,DAY,HARDING+(CORN)
MARTIN   79 PL B 86 93          A.D. MARTIN,M.R. PENNINGTON           (DURH)

DEFOIX   80 NP B 162 12         +DOBRZYNSKI,ANGELINI,BIGI,+      (CDEF+PISA)
HAMILTON 80 PRL                 +PUN,TRIPP,LAZARUS,NICHOLSON (LBL+BNL+MTHO)
ROZANSKA 80 NP B 162 505        +BLUM,DIETL,GRAYER,LORENZ+       (MPIM+CERN)
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X(1900–3600)

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46  X(1900-3600)

THIS ENTRY CONTAINS VARIOUS HIGH-MASS
NON-STRANGE PEAKS. OMITTED FROM TABLE.
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The high mass region is covered nearly continuously by evidence for peaks of various widths and decay modes. As a satisfactory grouping into particles is not yet possible, we list all the Y = 0 bumps coupled neither to $\bar{N}N$ nor to e^+e^-, and having M > 1900 MeV, together, ordered by increasing mass. Note that ANTIPOV 72 ($\pi^- p \to p\ MM^-$ at 25 and 40 GeV/c) see no narrow bumps.

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                 46  X(1900-3600)  MASSES AND WIDTHS  (MEV)

M       100(1898.)    (18.)             THOMPSON  74 HBC  +  13 PI+ P,2RHO    12/75
W       100 (108.)    (41.)    (27.)    THOMPSON  74 HBC  +  13 PI+ P,2RHO    12/75

M       100(1900.)    (40.)             BOESEBECK 68 HBC  +   8 PI+ P,PI+ PIO 12/75
W       100 (216.)   (105.)             BOESEBECK 68 HBC  +   8 PI+ P,PI+ PIO 12/75

M          (1970.)    (10.)             CHLIAPNIK 79 HBC   0 32 K+ P,2KS 2PI  12/79*
W          (1970.)    (10.)             CHLIAPNIK 79 HBC   0 32 K+ P,2KS 2PI  12/79*

M        30(1973.0)   (15.0)            CASC      70 HBC  - 11.2PI-P,RHO 2PI 12/75
W        30  (80.0)                     CASO      70 HBC  - 11.2PI-P,RHO 2PI 12/75

M   K    40(1975.0)   (12.0)            KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
W   K    40  (52.0)  OR LESS  CL=.90    KRAMER    70 HBC  +  13.1 PI+ P,2PI   12/75
    K    2PI PEAK OF KRAMER NOT SEEN IN SAME EXP WITH MORE DATA(THOMPSON 74)

M        50(2070.)                      TAKAHASHI 72 HBC     8. PI-P,N 2PI    12/75
W        50 (160.)                      TAKAHASHI 72 HBC     8. PI-P,N 2PI    12/75

M  E       (2157.0)   (10.0)            KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
W  E         (68.0)   (22.0)            KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
   E     EVIDENCE OF KRAMER 70 DISAPPEARED WITH MORE STATISTICS(THOMPSON 74)

M          (2190.0)   (10.0)            CLAYTON   67 HBC  +- 2.5PBAR,A2+OMEGA 10/67

M   C      (2207.0)   (22.0)            CASC      70 HBC  - 11.2PI- P,NOTE C  5/70
W   C       (130.0)                     CASO      70 HBC  - 11.2PI- P,NOTE C  5/70
    C    SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM)

M  B    126(2340.)    (20.)             BALTAY    75 HBC +   15 PI+P,P5PI     12/75
W  B    126 (180.)    (60.)             BALTAY    75 HBC +   15 PI+P,P5PI     12/75
   B     DOMINANT DECAY INTO RHOO RHOO PI+. BALTAY 78 FINDS CONFIRMATION
   B     IN 2PI+PI-2PIO EVENTS WHICH CONTAIN RHO+ RHOO PIO AND 2RHO+PI-.

M          (2500.0)   (32.0)            ANDERSON  69 MMS  -  16 PI- P,BACKW9  8/69
W            (87.0)                     ANDERSON  69 MMS  -  16 PI- P,BACKW9  8/69

M       550(2620.)    (20.)             BAUD      69 MMS  -  8.-10. PI- P     9/69
W       550  (85.)    (30.)             BAUD      69 MMS  -  8.-10. PI- P     9/69

M          (2676.0)   (27.0)            CASC      70 HBC  - 11.2PI- P,NOTE C  5/70
W           (150.0)                     CASO      70 HBC  - 11.2PI- P,NOTE C  5/70
    C    SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM)

M       640(2800.)    (20.)             BAUD      69 MMS  -  8.-10. PI- P     9/69
W       640  (46.)    (10.)             BAUD      69 MMS  -  8.-10. PI- P     9/69

M  C     15(2820.)    (10.)             SABAU     71 HBC  +  8. PI+ P        11/71
W  C     15  (50.)    (10.)             SABAU     71 HBC  +  8. PI+ P        11/71
   C     SEEN IN (K KBAR PI PI)+ MASS DISTRIBUTION

M       230(2880.)    (20.)             BAUD      69 MMS  -  8.-10. PI- P     9/69
W       230  (15.)   OR LESS            BAUD      69 MMS  -  8.-10. PI- P     9/69

M  Y     43(3013.)     (5.)             YOST      71 HBC  +  11.PI+ P,P(8PI)+ 11/71
W  Y     43  (40.)   OR LESS            YOST      71 HBC  +  11.PI+ P,P(8GI)   5/71
   Y     4.3 S.D. EFFECT  . DECAY TO 7 PIONS
   Y     NOT SEEN BY KALELKAR 75 WITH 5 TIMES MORE DATA

M          (3025.0)   (20.0)            BAUD      70 MMS  - 10.5-13 PI- P     5/70
W            (25.0)  APPROX.            BAUD      70 MMS  - 10.5-13 PI- 7     5/70

M          (3075.0)   (20.0)            BAUD      70 MMS  - 10.5-13 PI- P     5/70
W            (25.0)  APPROX.            BAUD      70 MMS  - 10.5-13 PI- P     5/70

M          (3145.0)   (20.0)            BAUD      70 MMS  - 10.5-15 PI- P     5/70
W            (10.0)  OR LESS            BAUD      70 MMS  - 10.5-15 PI- P     5/70

M          (3475.0)   (20.0)            BAUD      70 MMS  - 14-15.5 PI- P     5/70
W            (30.0)  APPROX.            BAUD      70 MMS  - 14-15.5 PI- P     5/70

M          (3535.0)   (20.0)            BAUD      70 MMS  - 14-15.5 PI- P     5/70
W            (30.0)  APPROX.            BAUD      70 MMS  - 14-15.5 PI- P     5/70

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REFERENCES FOR X(1900-3600)


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CLAYTON  67 HEIDBG.CONF.P.57   +MASON,MUIRHEAD,FILIPPAS+(LIVERPOOL+ATHENS)
BOESEBEC 68 NP B 4 501         BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
ANDERSON 69 PRL 22 1390        +COLLINS,+                          (BNL+CARN)
BAUD     69 PL  308 129        CERN BOSCN SPECTROMETER GROUP          (CERN)
BAUD     70 PL 31 B 549        CERN BOSCN SPECTROMETER GROUP          (CERN)
CASO     70 LNC 3 707          +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
KRAMER   70 PRL 25 396         +BARTON,GUTAY,LICHTMAN,MILLER,+      (PURDUE)
SABAU    71 LNC 1 514          +URETSKY                           (BUCH+ANL)
YOST     71 PR D 3 642         +MORRIS,ALBRIGHT,BRUCKER,LANNUTTI       (FSU)
TAKAHASH 72 PR D 6 1266        TAKAHASHI,BARISH,+      (TOHO+PENN+NDAM+ANL)
THOMPSON 74 NP B69 220         +GAIDOS,MCILWAIN,MILLER,MULERA,+       (PURD)
BALTAY   75 PRL 35 891         +CAUTIS,COHEN,KALELKAR,PISELLO,+(COLU+BING)
KALELKAR 75 THESIS(NEVIS 207) M.S.KALELKAR                            (CCLU)
KEMP     75 NC 27 A 155        +LOTTS,CONTRI,TEODORO+(DURH+GENO+MILA+LPNP)
BALTAY   78 PR D 17 52         +CAUTIS,COHEN,CSORNA,KALELKAR+  (COLU+BING)
BLANAR   79 PR D 20 615        +BOYER,EARLES,FAISSLER,GARELICK+       (NEAS)
CHLIAPNI 79  PREP.             CHLIAPNIKOV,GERDYUKOV,+      (SERP+BRUX+MONS)
CLINE    79 PRL 43 1771        +DE BONTE,GAIDOS,LEEDOM,KEY,+   (PURD+TNTO)
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e^+e^-(1100–3100)

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7  E+ E-(1100-3100,JPG=1- ) I=

THIS ENTRY CONTAINS NON-STRANGE
VECTOR MESONS COUPLED TO E+ E-(PHOTON)
BETWEEN PHI AND J/PSI MASS REGION.
SEE ALSO RHO PRIME(1250) AND RHO
PRIME(1600) MINI-REVIEW.
OMITTED FROM TABLE.

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             7  E+ E-(1100-3100) MASSES AND WIDTHS (MEV)

M          (1097.0)   (16.0)   (19.0)  BARTALUCC 79 OSPK    7 GAM P,E+ E- P  12/79*
W            (31.0)   (24.0)   (20.0)  BARTALUCC 79 OSPK    7 GAM P,E+ E- P  12/79*

M          (1652.0)   (17.0)           COSME     79 OSPK  0 E+ E-,3PI        12/79*
W            (42.0)   (17.0)           COSME     79 OSPK  0 E+ E-,3PI        12/79*

M  N P     (1665.0)   (10.0)           COSME     79 OSPK  0 E+ E-,5PI        12/79*
W            (37.0)   (21.0)           COSME     79 OSPK  0 E+ E-,5PI        12/79*
M  N     10 MEV SYSTEMATIC ERROR ADDED LINEARLY BY US
M    P   SEEN ALSO BY DELCOURT 79 WITH DM1 APPARATUS AT DCI

M  M       (1690.0)   (14.0)           COSME     79 OSPK    E+ E-,4PI        12/79*
W    R      (180.0)   (87.0)           COSME     79 OSPK    E+ E-,4PI        12/79*
M  M     NOT SEEN BY DELCOURT 79 WITH LARGER STATISTICS , NEITHER BY
M M      BACCI 80

M  I       1765 TO 1792                BARBIELLI 77 FRAB      E+ E-          12/77
W  I         47 TO 79                  BARBIELLI 77 FRAB      E+ E-          12/77

M    R     (1772.0)   (16.0)           COSME     79 OSPK 0  E+ E-,5PI        12/79*
W            (49.0)   (25.0)           COSME     79 OSPK 0  E+ E-,5PI        12/79*
M    R   NOT SEEN BY DELCOURT 79 , NEITHER BY SPINETTI 79

M  I       1812 TO 1836                BARBIELLI 77 FRAB      E+ E-          12/77
W  I         13 TO 34                  BARBIELLI 77 FRAB      E+ E-          12/77

M  S     58(1819.)     (7.)            BACCI     77 FRAG      E+ E-          12/77
W  S     58  (24.)     (9.)            BACCI     77 FRAG      E+ E-          12/77

M  S       (1821.)    (18.)            ESPOSITO  77 FRAM      E+ E-          12/77
W  S         (31.)    (25.)            ESPOSITO  77 FRAM      E+ E-          12/77

M          (1830.0)  APPROX.           PETERSON  78 SPEC    GAM P,K+ K- P
W           (120.0)  APPROX.           PETERSON  78 SPEC    GAM P,K+ K- P

M          (2130.)   APPROX.           ESPOSIT1  78 MEA     E+E-,K*(892)+..  12/78*
W            (30.)   APPROX.           ESPOSIT1  78 MEA     E+E-,K*(892)+..  12/78*

   I     SPREAD TAKES ACCOUNT OF POSSIBLE INTERFERENCE BETWEEN THE
   I     TWO STRUCTURES.
   S     SYSTEMATIC ERROR ADDED LINEARLY.

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Mesons

CHARMONIUM, X(2830), U(2980)

Data Card Listings

For notation, see key at front of Listings.

REFERENCES FOR E+ E-(1100-3100)


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BACCI     75 PL 58 B 481        +BIDOLI,PENSO,STELLA,BALDINI,+  (ROMA+FRAS)
BACCI     76 PL 64 B 356        +BIDOLI,PENSO,STELLA,BALDINI,+  (ROMA+FRAS)
BACCI     77 PL B 68 393        +DE ZORZI,PENSO,STELLA,BALDINI,+(ROMA+FRAS)
BARBIELL  77 PL B 68 397        BARBIELLINI,BARLETTA,+(FRAS+NAPL+PISA+SANI)
BARTALUC  77 NC A 39 374        BARTALUCCI BERTOLUCCI,BRADASCHIA(DESY+FRAS)
ESPOSITO  77 PL B 68 389        +FELICETTI,MARINI,+    (FRAS+NAPL+PADO+ROMA)
AMBROSIO  78 PL 80 B 141        +CERRITO,BEMPORAD,BROSCO,+ (NAPL+PISA+ROMA)
BALDINI   78 PL 78 B 167        +BATTISTONI,CAPON,BACCI,DEZORKI+(FRAS+RCMA)
ESPOSIT1  78 LNC 22 305         ESPOSITO,FELICETTI+    (FRAS+NAPL+PADO+ROMA)
ESPOSIT2  78 LNC 23 604         ESPOSITO,FELICETTI+    (FRAS+NAPL+PADO+RCMA)
PETERSON  78 PR D 18 3955       +DIXON,EHRLICH,GALIK,LARSON+      (CORN+HARV)
BARTALUC  79 NC 49 A 207        BARTALUCCI,BASINI,BERTOLUCCI+     (DESY+FRAS)
COSME     79 NP B 152 215       +DUDELZAK,GRELAUD,JEAN-MARIE,JULLIAN+ (IPN)
DELCOURT  79  PREP. LAL-79/21   +BERTRAND,BISELLO,BIZOT,BUON,CORDIER+(LALO)
ESPOSITO  79 LNC 25 5           +MARINI,PALLOTTA+      (FRAS+UMD+PADO+ROMA)
SPINETTI  79  PREP. LFN-79/65   M. SPINETTI                          (FRAS)
BACCI     80  PREP. LFN 80/2    +BALDINI,BATTISTONI,CAPCN,DE ZORZI+  (FRAS)
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The Charmonium System

We group into this system those meson states commonly believed to consist of charmed-quark-charmed-antiquark pairs. Since the discovery of the J/ψ(3100) (AUBERT 74, AUGUSTINI1 74) this family has increased to at least 13, of which we tabulate 9 as well established particles. Figure 1 shows the states of charmonium below the ψ(3685), interpreted by the charmonium model, at the time of the 1979 Chicago Lepton-Photon Conference: 1) the X(2830) and χ(3455) 0^{-+} candidates were not seen by the Crystal Ball Experiment (PARTRIDGE 79); 2) a new state, U(2980), had been discovered by examining the inclusive photon spectrum at the ψ(3685) mass.

X(2830) →

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54  X(2830,JPG=   ) I=

OBSERVED IN THE SEQUENTIAL RADIATIVE DECAY OF THE
J/PSI(3100) INTO X(2830) GAMMA, X(2830) INTO 2 GAMMAS
BY THE DASP AND DESY-HEIDELBERG GROUPS.
NOT SEEN BY THE CRYSTAL BALL (PARTRIDGE 79) WITH
MUCH LARGER STATISTICS.  OMITTED FROM TABLE.

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                         REFERENCES FOR X(2830)
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WIIK      75 STANFORD SYMP.69   B.H.WIIK                             (DESY)
BARTEL    76 TBILISI CONF.N56   +DUINKER,OLSSCN,HEINTZE,+       (DESY+HEID)
AMALDI    77 LNC 20 409         +BENEVENTANO,DELL,DOOHER+(ROMA+BNL+ADELPHI)
BRAUNSCH  77 PL 67 B 243        BRAUNSCHWEIG,+   (AACH+DESY+HAMB+MPIM+TOKY)
YAMADA    77 HAMB. CONF. P. 69  YAMADA           (AACH+HAMB+DESY+MUNC+TCKY)
APEL      78 PL 72 B 500        +AUGENSTEIN,+    (KARL+PISA+SERP+WIEN+CERN)
PARTRIDG  79  SLAC-PUB 2425     PARTRIDGE,PECK,+  (CIT+HARV+PRIN+SLAC+STAN)
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U(2980) →

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26  U(2980,JPG=   )I=

OBSERVED IN THE INCLUSIVE GAMMA SPECTRUM GENERATED FROM
PSI(3685) DECAY.NEEDS CONFIRMATION.OMITTED FROM TABLE.
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              26  U(2980) MASS (MEV)

M     1624(2980.0)   (20.0)         PARTRIDGE 79 CNTR    E+E-,GAMMA INCL. 12/79*
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              26  U(2980) WIDTH (MEV)

W     1624  (60.0)OR LESS           SCHARRE   79 RVUE    E+E-,GAMMA INCL. 12/79*
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                         REFERENCES FOR U(2980)
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PARTRIDG 79  SLAC-PUB 2425     PARTRIDGE,PECK,+  (CIT+HARV+PRIN+SLAC+STAN)
SCHARRE  79  SLAC-PUB 2426     D.L. SCHARRE
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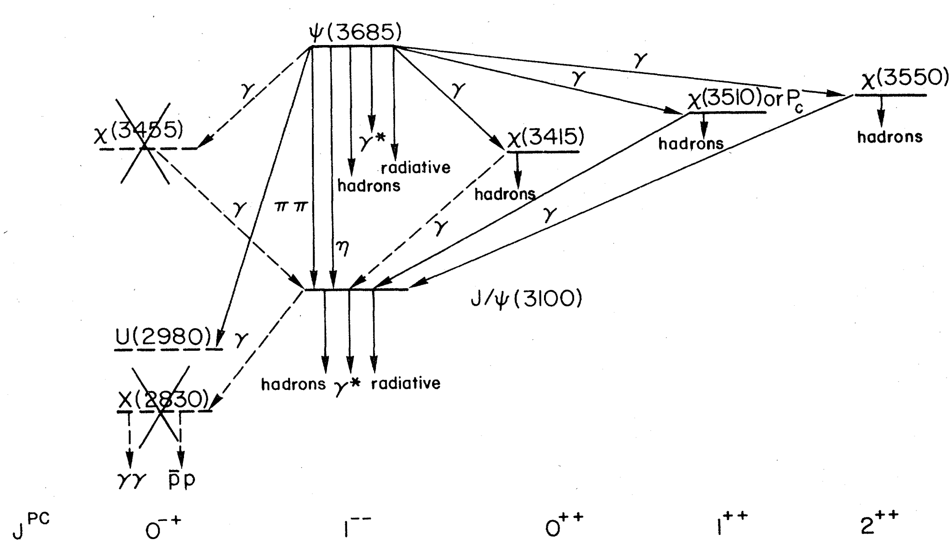

Fig. 1. The current state of knowledge of the charmonium system and transitions, as interpreted by the charmonium model. Uncertain states and transitions are indicated by dashed lines. J^{PC} quantum number assignments are in some cases tentative, but all are at least consistent with experiment; see individual particle listings for discussion. The notation γ* refers to decay processes involving decays to e^+e^- and $\mu^+\mu^-$. The crosses correspond to the states not seen by PARTRIDGE 79.

Data Card Listings

For notation, see key at front of Listings.

Mesons

J/ψ(3100)

J/ψ(3100) 70 J/PSI(3100,JPG=1--) I=0

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                        70  J/PSI(3100) MASS (MEV)

                   WE USE INDEPENDENT MEASUREMENTS OF THE J/PSI(3100)
                   MASS, THE PSI(3685) MASS AND THE MASS DIFFERENCE TO
                   PERFORM A CONSTRAINED FIT.

M          (3100.)                   AUBERT     74 SPEC    28. PP(E+E-)     2/75
M   L      (3105.)     (3.)          AUGUSTIN   74 SMAG          E+E-       2/75
M   O       3095.       4.           BOYARSKI   75 SMAG          E+E-       3/75
M   S       3089.5     31.           CRIEGEE1   75 PLUT          E+E-       2/75
M           3098.       6.           PREPOST    75 SPEC    13.-21.GAMMA D   1/76
M           3103.       6.           BEMPORAD   75 FRAB          E+E-       1/76
M           3096.0     30.0          SNYDER     76 SPEC    400 P BE,E+E-    1/77
M      9000(3095.44)   (0.46)        BARATE     79 SPEC  0 150 PI-BE,2MU   12/79*
M   F       3097.0      1.           BRANDELIK  79 DASP     E+ E-          12/79*
M          . . . . . . .
M   AVG     3097.05     0.94    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT3097.0       1.0     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M   FIT     3097.1      0.9     FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

M   F     FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
M   F     ASSUMING G(E+ E-) = G(MU+ MU-)
M
M   L     BOYARSKI 75 IS A REEVALUATION OF AUGUSTIN 74 BASED
M   L     ON A RECALIBRATION OF THE SPEAR BEAM ENERGY.
M
M   O     MASS, WIDTH, PARTIAL WIDTHS, AND BRANCHING RATIOS ALL OBTAINED
M   O     FROM ONE OVERALL FIT TO DATA OF THIS EXPERIMENT.
M
M   S     ERROR OF ABOUT 1 PER CENT FROM THE UNCERTAINTY IN CALIBRATION OF
M   S     THE BEAM ENERGY.
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                        70  J/PSI(3100) WIDTH (KEV)

W            69.       15.           BOYARSKI   75 SMAG          E+E-       3/75
W            68.       26.           BALDINI1   75 FRAG          E+E-       1/76
W            60.       25.           ESPOSITO   75 FRAM          E+E-       1/76
W   F        58.       13.           BRANDELIK  79 DASP     E+ E-          12/79*
W   F     FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
W   F     ASSUMING G(E+ E-) = G(MU+ MU-)
W          . . . . . . . .
W   AVG      63.0       8.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W   STUDENT  63.0       9.3     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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                        70  J/PSI(3100) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      J/PSI(3100) INTO E+ E-                            .5+  .5
P2      J/PSI(3100) INTO MU+ MU-                          105+ 105
P3      J/PSI(3100) INTO HADRONS
P4      J/PSI(3100) INTO VIRTUAL GAMMA INTO HADRONS

P       HADRONIC DECAYS
P       ---------------
P11     J/PSI(3100) INTO PI+ PI-                          139+ 139
P12     J/PSI(3100) INTO PI+ PI- PIO                      139+ 139+ 134
P13     J/PSI(3100) INTO 2(PI+ PI-)                       139+ 139+ 139+ 139
P14     J/PSI(3100) INTO 2(PI+ PI-) PIO
P15     J/PSI(3100) INTO 3(PI+ PI-)
P16     J/PSI(3100) INTO 3(PI+ PI-) PIO
P17     J/PSI(3100) INTO 4(PI+ PI-)
P18     J/PSI(3100) INTO 4(PI+ PI-) PIO
P19     J/PSI(3100) INTO K KBAR                           497+ 497
P20     J/PSI(3100) INTO K KBAR PI                        497+ 497+ 139
P21     J/PSI(3100) INTO PI+ PI- K+ K-                    139+ 139+ 497+ 497
P22     J/PSI(3100) INTO 2(PI+ PI-) K+ K-
P23     J/PSI(3100) INTO PI+ PI- PIO K+ K-
P24     J/PSI(3100) INTO RHO PI                           776+ 139
P25     J/PSI(3100) INTO RHO PI PI PI                     776+ 139+ 139+ 139
P26     J/PSI(3100) INTO OMEGA PI PI                      782+ 139+ 139
P27     J/PSI(3100) INTO OMEGA 4PI                        782+ 139+ 139+ 139+
P28     J/PSI(3100) INTO OMEGA K KBAR                     782+ 497+ 497
P29     J/PSI(3100) INTO OMEGA F                          782+1273
P30     J/PSI(3100) INTO OMEGA F PRIME                    782+1516
P31     J/PSI(3100) INTO PHI PI PI                        1019+ 139+ 139
P32     J/PSI(3100) INTO PHI 2(PI+ PI-)
P33     J/PSI(3100) INTO PHI K KBAR                       1019+ 497+ 497
P34     J/PSI(3100) INTO PHI ETA                          1019+ 548
P35     J/PSI(3100) INTO PHI ETA PRIME                    1019+ 957
P36     J/PSI(3100) INTO PHI F                            1019+1273
P37     J/PSI(3100) INTO PHI F PRIME                      1019+1516
P38     J/PSI(3100) INTO A2 PI                            1317+ 139
P39     J/PSI(3100) INTO A2 RHO                           1317+ 776
P40     J/PSI(3100) INTO K K*(892)                        497+ 892
P41     J/PSI(3100) INTO K K*(1430)                       497+1434
P42     J/PSI(3100) INTO K*(892) K*(892)                  892+ 892
P43     J/PSI(3100) INTO K*(1430) K*(1430)                1434+1434
P44     J/PSI(3100) INTO K*(892) K*(1430)                 892+1434
P45     J/PSI(3100) INTO P PBAR                           938+ 938
P46     J/PSI(3100) INTO P PBAR PI                        938+ 938+ 139
P47     J/PSI(3100) INTO P NBAR PI                        938+ 939+ 139
P48     J/PSI(3100) INTO P PBAR PI+ PI-                   938+ 938+ 139+ 139
P49     J/PSI(3100) INTO P PBAR PI+ PI- PIO
P50     J/PSI(3100) INTO P PBAR ETA                       938+ 938+ 548
P51     J/PSI(3100) INTO P PBAR OMEGA                     938+ 938+ 782
P52     J/PSI(3100) INTO LAMBDA ANTILAMBDA                1115+1115
P53     J/PSI(3100) INTO LAMBDA ANTISIGMA                 1115+1192
P54     J/PSI(3100) INTO XI ANTIXI                        1314+1314
P55     J/PSI(3100) INTO PI B                             139+1231
P56     J/PSI(3100) INTO P PBAR ETA PRIME                 938+ 938+ 957
P57     J/PSI(3100) INTO SIGMAO SIGMABARO                 1192+1192

P       RADIATIVE DECAYS
P       ----------------
P70     J/PSI(3100) INTO GAMMA GAMMA                        0+   0
P71     J/PSI(3100) INTO 3 GAMMA                            0+   0+   0
P72     J/PSI(3100) INTO PIO GAMMA                        134+   0
P73     J/PSI(3100) INTO ETA GAMMA                        548+   0
P74     J/PSI(3100) INTO ETA PRIME GAMMA                  957+   0
P75     J/PSI(3100) INTO X(2830) GAMMA                   2830+   0
P76     J/PSI(3100) INTO F GAMMA                         1273+   0
P77     J/PSI(3100) INTO F PRIME GAMMA                   1516+   0
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                  70  J/PSI(3100) PARTIAL WIDTHS (KEV)

W1      J/PSI(3100) INTO E+ E-                             (G1)
W1           4.8       0.6          BOYARSKI   75 SMAG          E+E-       3/75
W1   B      (4.6)     (.8)          BALDINI1   75 FRAG          E+E-       1/76
W1           4.6       1.0          ESPOSITO   75 FRAM          E+E-       1/76
W1   B    ASSUMING EQUAL PARTIAL WIDTHS FOR (E+E-) AND (MU+MU-)
W1 F         4.4       0.6          BRANDELIK  79 DASP     E+ E-          12/79*
W1 F      FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
W1 F      ASSUMING G(E+ E-) = G(MU+ MU-)
W1         . . . . . . . .
W1   AVG     4.60      0.39    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W1   STUDENT 4.60      0.42    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W2      J/PSI(3100) INTO MU+ MU-                           (G2)
W2           4.8       0.6          BOYARSKI   75 SMAG          E+E-       3/75
W2           5.0       1.0          ESPOSITO   75 FRAM          E+E-       1/76
W2         . . . . . . . .
W2   AVG     4.85      0.51    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W2   STUDENT 4.85      0.55    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W3      J/PSI(3100) INTO HADRONS                           (G3)
W3          59.       14.           BOYARSKI   75 SMAG          E+E-       3/75
W3          59.       24.           BALDINI1   75 FRAG          E+E-       1/76
W3          50.       25.           ESPOSITO   75 FRAM          E+E-       1/76
W3         . . . . . . . .
W3   AVG    57.3      10.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W3   STUDENT 57.3     11.7     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W4      J/PSI(3100) INTO GAMMA INTO HADRONS
W4 C        12.        2.           BOYARSKI   75 SMAG          E+E-       1/76
W4 C     INCLUDED IN W3

W5      J/PSI(3100) INTO GAMMA GAMMA   (EV)                (G4)
W5          (5.4)OR LESS CL=0.90    BRANDELIK  79 DASP     E+ E-          12/79*
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                  70  J/PSI(3100) BRANCHING RATIOS

         FOR THE BRANCHING RATIOS R1 - R4, SEE ALSO THE PARTIAL
         WIDTHS ABOVE, AND (PARTIAL WIDTHS)*R1 BELOW.

R1      J/PSI(3100) INTO (E+ E-)/TOTAL                     (P1)/(P1+P2+P3)
R1          0.069     0.009         BOYARSKI   75 SMAG          E+E-       3/75

R2      J/PSI(3100) INTO (MU+ MU-)/TOTAL                   (P2)/(P1+P2+P3)
R2          0.069     0.009         BOYARSKI   75 SMAG          E+E-       3/75

R3      J/PSI(3100) INTO (HADRONS)/TOTAL                   (P3)/(P1+P2+P3)
R3          0.86      0.02          BOYARSKI   75 SMAG          E+E-       3/75

R4      J/PSI(3100) INTO (E+ E-)/(MU+ MU-)                 (P1)/(P2)
R4          1.00      0.05          BOYARSKI   75 SMAG          E+E-       3/75
R4          0.93      0.10          FORD       75 SPEC          E+E-       2/75
R4           .91       .15          ESPOSITO   75 FRAM          E+E-       1/76
R4         . . . . . . . .
R4   AVG    0.980     0.043    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4   STUDENT 0.980    0.047    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R5      J/PSI(3100) INTO (GAMMA INTO HADRONS)/TOTAL
R5 C         .17       .02          BOYARSKI   75 SMAG          E+E-       1/76
R5 C     INCLUDED IN R3

R       HADRONIC DECAYS
R       ---------------

R8      J/PSI(3100) INTO (PI+ PI-)/TOTAL         (UNITS 10**-4)
R8       1    1.6       1.6         VANNUCCI   77 SMAG          E+E-       1/77
R8       5    1.0       0.5         BRANDELIK  78 DASP          E+E-      12/78*
R8         . . . . . . . .
R8   AVG    1.05      0.48     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8   STUDENT 1.05     0.52     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R9      J/PSI(3100) INTO (2(PI+ PI-))/TOTAL
R9     76     .004      .001         JEAN-MARI  76 SMAG          E+E-       1/76

R10     J/PSI(3100) INTO (2(PI+ PI-) PIO)/TOTAL
R10   675     .04       .01          JEAN-MARI  76 SMAG          E+E-       1/76
R10  1500    0.0364    0.0052        BURMESTER  77 PLUT          E+E-      12/77
R10        . . . . . . . .
R10 AVG      0.0372    0.0046  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R10 STUDENT  0.0372    0.0050  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R11     J/PSI(3100) INTO (3(PI+ PI-))/TOTAL
R11    32     .004      .002         JEAN-MARI  76 SMAG          E+E-       1/76

R12     J/PSI(3100) INTO (3(PI+ PI-) PIO)/TOTAL
R12   181     .029      .007         JEAN-MARI  76 SMAG          E+E-       1/76

R13     J/PSI(3100) INTO (4(PI+ PI-) PIO)/TOTAL
R13    13     .009      .003         JEAN-MARI  76 SMAG          E+E-.      1/76

R14     J/PSI(3100) INTO (PI+ PI- K+ K-)/TOTAL
R14   205    0.0072    0.0023        VANNUCCI   77 SMAG          E+E-       1/77

R15     J/PSI(3100) INTO (2(PI+ PI-) K+ K-)/TOTAL
R15    30    0.0031    0.0013        VANNUCCI   77 SMAG          E+E-       1/77

R16     J/PSI(3100) INTO (RHO PI)/(PI+ PI- PIO)
R16          (.7)  OR MORE  CL=0.90  JEAN-MARI  76 SMAG          E+E-       1/76

R17     J/PSI(3100) INTO (RHOO PIO)/(RHO+- PI-+)
R17          0.63      0.22         BARTEL 1   76 CNTR          E+E-       1/77
R17          0.59      0.17         JEAN-MARI  76 SMAG          E+E-       1/76
R17          0.53      0.15         ALEXANDER  78 PLUT     E+ E-           4/78*
R17          0.46      0.14         BRANDELIK  78 DASP     E+E-,PI+PI-GAMMA  4/78*
R17         (0.56)    (0.06)        SCHARRE    79 SMAG     E+E-           12/79*
R17        . . . . . . . .
R17 AVG      0.534     0.081   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R17 STUDENT  0.534     0.088   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R18     J/PSI(3100) INTO (RHO PI)/TOTAL
R18   543    0.010     0.002        BARTEL 1   76 CNTR          E+E-       1/77
R18   153    0.013     0.003        JEAN-MARI  76 SMAG          E+E-       1/76
R18   183    0.016     0.004        ALEXANDER  78 PLUT     E+ E-           4/78*
R18          0.0133    0.0021       BRANDELIK  78 DASP     E+E-,PI+PI-GAMMA  4/78*
R18         (0.0132)  (0.0021)      SCHARRE    79 SMAG     E+E-           12/79*
R18        . . . . . . . .
R18 AVG      0.0122    0.0012  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R18 STUDENT  0.0123    0.0014  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R19     J/PSI(3100) INTO (OMEGA PI PI)/(2(PI+ PI-) PIO)
R19  J       (.2)                   JEAN-MARI  76 SMAG          E+E-       1/76
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Mesons

J/ψ(3100)

Data Card Listings

For notation, see key at front of Listings.

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R20     J/PSI(3100) INTO (RHO PI PI PI)/(2 (PI+ PI-) PIO)
R20  J          (.3)                   JEAN-MARI 76 SMAG          E+E-        1/76

R21     J/PSI(3100) INTO (PHI PI+ PI-)/TOTAL
R21    23    0.0021   0.0009           FELDMAN   77 SMAG          E+E-       12/77

R22     J/PSI(3100) INTO (KOS KOL)/TOTAL  (UNITS 10**-4)
R22           (0.89) OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-        1/77

R23     J/PSI(3100) INTO (K+ K-)/TOTAL     (UNITS 10**-4)
R23     2    2.0      1.6              VANNUCCI  77 SMAG          E+E-        1/77
R23     7    2.2      0.9              BRANDELIK 79 DASP     E+ E-           12/79*
R23           . . . . . . . . .
R23 AVG      2.15     0.78     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R23 STUDENT  2.15     0.84     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R24     J/PSI(3100) INTO (KO K*(892)O)/TOTAL
R24    45    0.0027   0.0006           VANNUCCI  77 SMAG          E+E-        1/77

R25     J/PSI(3100) INTO (K+- K*(892)-+)/TOTAL
R25    39    0.0041   0.0012           BRAUNSCHW 76 DASP          E+E-        1/77
R25    48    0.0032   0.0006           VANNUCCI  77 SMAG          E+E-        1/77
R25           . . . . . . . . .
R25 AVG      0.00338  0.00054  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R25 STUDENT  0.00338  0.00059  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R26     J/PSI(3100) INTO (KO K*(1430)O)/TOTAL
R26          (0.002) OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-        1/77

R27     J/PSI(3100) INTO (K+- K*(1420-+)/TOTAL
R27          (0.0033)OR LESS  CL=0.90  BRAUNSCHW 76 DASP          E+E-        1/77
R27          (0.0015)OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-        1/77

R28     J/PSI(3100) INTO (K*(892)O K*(892)O)/TOTAL
R28          (0.0005)OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-        1/77

R29     J/PSI(3100) INTO (K*(1430)O K*(1430)O)/TOTAL
R29          (0.0029)OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-        1/77

R30     J/PSI(3100) INTO (K*(892)O K*(1430)O)/TOTAL
R30    40    0.0067   0.0026           VANNUCCI  77 SMAG          E+E-        1/77


R31     J/PSI(3100) INTO (PBAR P)/TOTAL    (UNITS 10**-3)
R31          2.0      0.5              BESCH     78 CNTR          E+E-        4/78*
R31  A 331   2.2      0.2              PERUZZI   78 SMAG          E+E-        4/78*
R31   133    2.5      0.4              BRANDELIK 79 DASP     E+ E-           12/79*
R31           . . . . . . . . .
R31 AVG      2.23     0.17     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R31 STUDENT  2.23     0.18     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R32     J/PSI(3100) INTO (PBAR P)/(MU+ MU-)
R32  A  20   (.051)   (.02)            CRIEGEE2  75 PLUT          E+E-        1/76

R33     J/PSI(3100) INTO (LAMBDA ANTILAMBDA)/TOTAL (UNITS 10**-3)
R33   156    1.1      0.2              PERUZZI   78 SMAG     E+E-,L X,LBAR L  4/78*

R34     J/PSI(3100) INTO (P PBAR PIO)/TOTAL (UNITS 10**-3)
R34   109    1.00     0.15             PERUZZI   78 SMAG     E+E-,P PB        4/78*
R34          1.4      0.4              BRANDELIK 79 DASP     E+ E-           12/79*
R34           . . . . . . . . .
R34 AVG      1.05     0.14     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R34 STUDENT  1.05     0.15     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R35     J/PSI(3100) INTO (P PBAR PI+PI-)/TOTAL (UNITS 10**-3)
R35   533    5.5      0.6              PERUZZI   78 SMAG     E+E-,P PB 1-2PI  4/78*

R36     J/PSI(3100) INTO (P PBAR PI+ PI- PIO)/TOTAL (UNITS 10**-3)
R36     INCLUDING P PBAR PI+PI- GAMMA AND EXCLUDING OMEGA,ETA,ETA PRIME
R36    39    1.6      0.6              PERUZZI   78 SMAG     E+E-,P PB 2PI    4/78*

R37     J/PSI(3100) INTO (LAMBDA ANTISIGMA)/TOTAL (UNITS 10**-3)
R37          (0.15) OR LESS  CL=0.90   PERUZZI   78 SMAG     E+E-,LAMBDA X    4/78*

R38     J/PSI(3100) INTO (PI+- A2)/TOTAL
R38          (0.0043)OR LESS  CL=0.90  BRAUNSCHW 76 DASP          E+E-        1/77

R39     J/PSI(3100) INTO (OMEGA PI PI)/TOTAL
R39   215    0.0078   0.00216          BURMESTER 77 PLUT          E+E-       12/77
R39   348    0.0068   0.0019           VANNUCCI  77 SMAG          E+E-        1/77
R39           . . . . . . . . .
R39 AVG      0.0068   0.0019   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R39 STUDENT  0.0068   0.0021   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R40     J/PSI(3100) INTO 2(K+ K-)/TOTAL
R40          0.0007   0.0003           VANNUCCI  77 SMAG          E+E-        1/77

R41     J/PSI(3100) INTO (OMEGA K KBAR)/TOTAL
R41    22    0.0016   0.0010           FELDMAN   77 SMAG          E+E-       12/77

R42     J/PSI(3100) INTO (PHI K KBAR)/TOTAL
R42    14    0.0018   0.0008           FELDMAN   77 SMAG          E+E-       12/77

R43     J/PSI(3100) INTO (PHI ETA)/TOTAL
R43     5    0.0010   0.0006           VANNUCCI  77 SMAG          E+E-        1/77

R44     J/PSI(3100) INTO (PHI ETA PRIME)/TOTAL
R44          (0.0013)OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-        1/77

R45     J/PSI(3100) INTO (PHI F PRIME)/TOTAL
R45     6    0.0008   0.0005           VANNUCCI  77 SMAG          E+E-        1/77

R46     J/PSI(3100) INTO (P NBAR PI-)/TOTAL (UNITS 10**-3)
R46   194    2.16     0.29             PERUZZI   78 SMAG     E+E-,P PI-       4/78*
R46B  204    2.04     0.27             PERUZZI   78 SMAG     E+E-,P PI+       4/78*
R46B    FROM ANTI-CHANNEL (PBAR N PI+)
R46           . . . . . . . . .
R46 AVG      2.10     0.20     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R46 STUDENT  2.10     0.21     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R47     J/PSI(3100) INTO (P PBAR ETA)/TOTAL (UNITS 10**-3)
R47   197    2.3      0.4              PERUZZI   78 SMAG     E+E-,P PB 0-2PI  4/78*
R47          2.5      1.2              BRANDELIK 79 DASP     E+ E-           12/79*
R47           . . . . . . . . .
R47 AVG      2.32     0.38     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R47 STUDENT  2.32     0.41     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R48     J/PSI(3100) INTO (P PBAR OMEGA)/TOTAL (UNITS 10**-3)
R48    77    1.6      0.3              PERUZZI   78 SMAG     E+E-,P PB 1-2PI  4/78*

R49     J/PSI(3100) INTO (KOS K+- PI-+)/TOTAL
R49   126    0.0026   0.0007           VANNUCCI  77 SMAG          E+E-        1/77

R50     J/PSI(3100) INTO (PHI F)/TOTAL     (UNITS 10**-4)
R50          (3.7)  OR LESS  CL=0.90   VANNUCCI  77 SMAG          E+E-        1/77
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R51     J/PSI(3100) INTO (PHI 2(PI+PI-))/TOTAL
R51          (0.0015)OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-        1/77

R52     J/PSI(3100) INTO (OMEGA F)/TOTAL
R52    81    0.0019   0.0008           VANNUCCI  77 SMAG          E+E-        1/77
R52    70    0.0040   0.0016           BURMESTER 77 PLUT          E+E-       12/77
R52           . . . . . . . . .
R52 AVG      0.00232  0.00084  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R52 STUDENT  0.00230  0.00081  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R53     J/PSI(3100) INTO (OMEGA F PRIME)/TOTAL  (UNITS 10**-4)
R53          (1.6)  OR LESS  CL=0.90   VANNUCCI  77 SMAG          E+E-        1/77

R54     J/PSI(3100) INTO (PI+PI-PIO K+K-)/TOTAL
R54   309    0.012    0.003            VANNUCCI  77 SMAG          E+E-        1/77

R55     J/PSI(3100) INTO (RHO A2)/TOTAL
R55    36    0.0084   0.0045           VANNUCCI  77 SMAG          E+E-        1/77

R56     J/PSI(3100) INTO (OMEGA 2PI+ 2PI-)/TOTAL
R56   140    0.0085   0.0034           VANNUCCI  77 SMAG          E+E-        1/77

R57     J/PSI(3100) INTO (XI- ANTIXI-)/TOTAL (UNITS 10**-3)
R57    51    1.4      0.5              PERUZZI   78 SMAG     E+E-,XI-X        4/78*
R57  C 71    (3.2)    (0.8)            PERUZZI   78 SMAG     E+E-,L LBAR      4/78*
R57  C  INCLUDES CHANNEL (XIO ANTIXIO)

R58     J/PSI(3100) INTO (RHO+- PI-+)/(K*(892)+- K-+)
R58          (0.26)   (0.09)           PIERRE    76 SMAG          E+E-        4/77

R59     J/PSI(3100) INTO (B+- PI-+)/TOTAL
R59    87    0.0029   0.0007           BURMESTER 77 PLUT          E+E-       12/77

R60     J/PSI(3100) INTO (N NBAR)/TOTAL (UNITS 10**-2)
R60          0.18     0.09             BESCH     78 CNTR          E+E-        4/78*

R61     J/PSI(3100) INTO (SIGMAO SIGMABARO)/TOTAL (UNITS 10**-3)
R61    52    1.3      0.4              PERUZZI   78 SMAG     E+E-,L LBAR      4/78*

R62     J/PSI(3100) INTO (P PBAR ETA PRIME)/TOTAL (UNITS 10**-3)
R62    19    1.8      0.6              PERUZZI   78 SMAG     E+E-,P PB 1-2PI  4/78*

R     J  FINAL STATE  2(PI+PI-)PIO
R     A  ASSUMING ANGULAR DISTRIBUTION (1.+COS(THETA)**2)


R       RADIATIVE DECAYS
R       ----------------

R71     J/PSI(3100) INTO (2 GAMMA)/TOTAL  (UNITS 10**-3) (P4)
R71          (0.5)  OR LESS  CL=0.90   BARTEL    77 CNTR          E+E-        4/77

R72     J/PSI(3100) INTO (PIO GAMMA)/TOTAL (UNITS 10**-3)
R72    10    0.073    0.047            BRANDELIK 79 DASP     E+ E-           12/79*

R73     J/PSI(3100) INTO (ETA GAMMA)/TOTAL (UNITS 10**-3)
R73    21    1.3      0.4              BARTEL    77 CNTR     E+E-,3 GAMMA     1/77
R73          0.82     0.10             BRANDELIK 79 DASP     E+ E-           12/79*
R73          (1.17)   (0.17)           PARTRIDGE 79 CNTR     E+ E-,3 GAMMA   12/79*
R73           . . . . . . . . .
R73 AVG      0.85     0.11     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R73 STUDENT  0.85     0.11     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R74     J/PSI(3100) INTO (ETA PRIME GAMMA)/TOTAL  (UNITS 10**-3)
R74          (3.3)  OR LESS  CL=.90    BACCI     76 FRAG          E+E-        4/77
R74    57    2.4      0.7              BARTEL 1  76 CNTR     E+E-,2 GAMMA RHO 1/77
R74     6    2.9      1.1              BRANDELIK 79 DASP     E+E-,3 GAMMA    12/79*
R74          (6.87)   (1.71)           PARTRIDGE 79 CNTR     E+ E-,3 GAMMA   12/79*
R74B         (3.8)    (1.3)            SCHARRE   79 SMAG     E+E-, GAMMA X   12/79*
R74B    FROM THE INCLUSIVE GAMMA DECAY SPECTRUM                              12/78*
R74          (3.4)    (0.7)            SCHARRE   79 SMAG     E+E-,2 PI 2GAMMA 12/79*
R74           . . . . . . . . .
R74 AVG      2.54     0.59     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R74 STUDENT  2.54     0.64     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R75     J/PSI(3100) INTO (ETA PRIME GAMMA)/(ETA GAMMA)
R75          (7.9)    (3.6)            PARTRIDGE 79 CNTR     E+ E-,3 GAM 2PI 12/79*

R76     J/PSI(3100) INTO (X(2830) GAMMA)/TOTAL,X TO 2 GAMMA (UNITS 10**-3)
R76  X       (0.32) OR LESS  CL=0.90   BARTEL    77 CNTR     E+E-,3 GAMMA    12/77
R76    19    0.14     0.04             YAMADA    77 DASP     E+E-,3 GAMMA    12/77
R76          (0.022)OR LESS CL=0.90    PARTRIDGE 79 CNTR     E+ E-,3 GAM 2PI 12/79*
R76  X  EXISTENCE OF X(2830) IN BARTEL 2 76 DATA IS ONLY 2 STD EFFECT          3/77

R78     J/PSI(3100) INTO (3 GAMMA)/TOTAL  (UNITS 10**-3)
R78  U       (0.08) OR LESS  CL=0.90   BRAUNSCHW 77 DASP     E+E-,3 GAMMA     1/77
R78          (0.055) OR LESS CL=0.90   PARTRIDGE 79 CNTR     E+E-,3 GAMMA    12/79*
R78  U  RE-STATED BY US USING TOTAL WIDTH 67 KEV.

R80     J/PSI(3100) INTO (GAMMA + 2 OR MORE NEUTRALS)/TOTAL   (UNITS 10**-3)
R80          7.0      2.0              BARTEL    77 CNTR          E+E-        1/77

R81     J/PSI(3100) INTO (F GAMMA)/TOTAL (UNITS 10**-3)
R81    35    2.0      0.7              ALEXANDER 78 PLUT   0 E+E-             4/78*
R81  T 30    1.2      0.6              BRANDELIK 78 DASP     E+E-,PI+PI-GAMMA 4/78*
R81  T  RE-STATED BY US TO TAKE ACCOUNT OF SPREAD OF E1,M2,E3 TRANSITIONS.
R81           . . . . . . . . .
R81 AVG      1.54     0.46     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R81 STUDENT  1.54     0.51     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R82     J/PSI(3100) INTO (F PRIME GAMMA)/TOTAL (UNITS 10**-3)
R82     3    (0.23) OR LESS  CL=0.90   ALEXANDE2 78 PLUT     E+E-,K+K- GAMMA  4/78*
R82  S  4    (0.34) OR LESS  CL=0.90   BRANDELIK 79 DASP     E+E-,PI+PI-GAMMA 12/79*
R82  S  ASSUMING ISOTROPIC PRODUCTION AND DECAY OF THE F PRIME,AND ISOSPIN.

R84     J/PSI(3100) INTO (P PBAR GAMMA)/TOTAL (UNITS 10**-3)
R84          (0.11) OR LESS  CL=0.90   PERUZZI   78 SMAG     E+E-,P PB SHOWER 4/78*

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                   70  J/PSI(3100)      G(I)*G(E+E-)/G(TOTAL)    (KEV)

           THIS COMBINATION OF A PARTIAL WIDTH WITH THE PARTIAL WIDTH
           INTO E+E- AND WITH THE TOTAL WIDTH IS OBTAINED FROM THE INTEGRATED
           CROSS-SECTION INTO CHANNEL(I) IN THE E+E- ANNIHILATION.
           WE ONLY LIST DATA NOT HAVING BEEN USED TO DETERMINE THE PARTIAL
           WIDTH G(I) OR THE BRANCHING RATIO G(I)/TOTAL.

G1      G(E+E-)*G(E+E-)/G(TOTAL)
G1   S       (.32)    (.07)            BALDINI1  75 FRAG          E+E-        1/76
G1            .34      .14             BEMPORAD  75 FRAB          E+E-        1/76
G1   S       (.34)    (.09)            ESPOSITO  75 FRAM          E+E-        1/76
G1   S       (.36)    (.10)            FORD      75 SPEC          E+E-
G1           0.35     0.02             BRANDELIK 79 DASP          E+E-       12/79*
G1            . . . . . . . . .
G1   AVG     0.350    0.020    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
G1   STUDENT 0.350    0.021    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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Data Card Listings

Mesons

For notation, see key at front of Listings. J/ψ(3100), χ(3415), χ(3455), P_c or χ(3510)

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G2      G(MU+MU-)*G(E+E-)/G(TOTAL)
G2             .31        .09          BEMPORAD  75 FRAB        E+E-          1/76
G2            (.32)      (.08)         CRIEGEE2  75 PLUT        E+E-          1/76
G2             .51        .09          DASP1     75 DASP        E+E-          1/76
G2   S        (.38)      (.05)         ESPOSITO  75 FRAM        E+E-          1/76
G2   S        (.46)      (.10)         LIBERMAN  75 SPEC        E+E-          1/76
G2          . . . . . . . . .
G2   AVG      0.41       0.10     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
G2   STUDENT  0.410      0.079    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

G3      G(HADRONIC)*G(E+E-)/G(TOTAL)
G3   S       (4.)       (.8)           BALDINI1  75 FRAG        E+E-          1/76
G3   S       (3.9)      (.8)           ESPOSITO  75 FRAM        E+E-          1/76

G    S   SEE THE BRANCHING RATIOS AND PARTIAL WIDTHS ABOVE.

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REFERENCES FOR J/PSI(3100)


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CHRISTEN 70 PRL 25 1523          CHRISTENSON,HICKS,LEDERMAN+ (COLU+BNL+CERN)

ABRAMS   74 PRL 33 1453          +BRIGGS,AUGUSTIN,BOYARSKI+         (LBL+SLAC)
ASH      74 NCL 11 705           +ZORN,BARTOLI+     (FRAS+UMD+NAPL+PADO+ROMA)
AUBERT   74 PRL 33 1404          +BECKER,BIGGS,BURGER,CHEN,EVERHART(MIT+BNL)
AUGUSTIN 74 PRL 33 1406          +BOYARSKI,ABRAMS,BRIGGS+           (SLAC+LBL)
BACCI    74 PRL 33 1408          +BARTOLI,BARBARINO,BARBIELLINI+   (FRASCATI)
   ALSO  74 PRL 33 1649          FOR ERRATA
BALDINI- 74 NCL 11 711           BALDINI-CELIO,BACCI+          (FRASCATI+ROMA)
BARBIELL 74 NCL 11 718           BARBIELLINI,BEMPORAD+ (FRAS+NAPL+PISA+ROMA)
BRAUNSCH 74 PL 53B 393           BRAUNSCHWEIG+       (AACHEN+HAMB+MUNICH+TOKYO)

ANDREWS  75 PRL 34 231           +HARVEY,LOBKOWICZ,MAY,NORDBERG   (ROCH+CCRN)
AUBERT   75 NP B 89 1            +BECKER,BIGGS,BURGER,GLENN,+        (MIT+BNL)
BACCI    75 NCL 12 269           +PENSO,STELLA,BALDINI-CELIO,+    (ROMA+FRAS)
BALDINI1 75 PL 58B 471           BALDINI-CELIO,BOZZO,CAPON,BACCI+(FRAS+RCMA)
BALDINI2 75 PL 58B 475           BALDINI-CELIO,CAPON,DEL FABBRO+ (FRAS+ROMA)
BEMPORAD 75 STANFORD SYMP.113 C.BEMPORAD                    (PISA+FRASCATI)
BLANAR   75 PRL 35 346           +BOYER,FAISSLER,GARELICK,GETTNER,+   (NEAS)
BOYARSKI 75 PRL 34 1357          +BREIDENBACH,BULOS,FELDMAN,+     (SLAC+LBL)JPC
BRAUNSCH 75 PL 53B 491           BRAUNSCHWEIG+       (AACHEN+HAMB+MUNICH+TOKYO)
BUSSER   75 PL 56 B 482          +BLUMENFELD,BANNER,+  (CERN+COLU+ROCK+SACL)
CAMERINI 75 PRL 35 483           +LEARNED,PREPOST,ASH,ANDERSON,+ (WISC+SLAC)
CRIEGEE1 75 PL 53B 489           +DEHNE,FRANKE,HORLITZ,KRECHLOCK+      (DESY)
CRIEGEE2 75  DESY PREP.75/32     +DEHNE,FOX,FRANKE,HORLITZ,KNIES,+     (DESY)
DAKIN    75 PL 56 B 405          +KREISLER,BOLON,HEILE+       (MASA+MIT+SLAC)
DASP1    75 PL 56B 491           BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
DASP2    75 PL 57B 297           BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TCKY)
ESPOSITO 75 NCL 14 73            +BARTOLI,BISELLO,+     (FRAS+NAPL+PADO+ROMA)
FORD     75 PRL 34 604           +BERON,HILGER,HOFSTADTER+         (SLAC+PENN)
GITTELMA 75 PRL 35 1616          GITTELMAN+HANSON+LARSON+LOH+           (CORN)
GRECO    75 PL 56B 367           +PANCHERI-SRIVASTAVA,SRIVASTAVA        (FRAS)
HEINTZE  75 STANFORD SYMP.97     J.HEINTZE                        (HEIDELBERG)
JACKSON  75 NIM 128 13           J.D.JACKSON,D.SCHARRE                   (LBL)
KNAPP1   75 PRL 34 1040          +LEE,BRONSTEIN+    (COLU+HAWA+CORN+ILL+FNAL)
KNAPP2   75 PRL 34 1044          +LEE,BRONSTEIN+    (COLU+HAWA+CORN+ILL+FNAL)
LIBERMAN 75 STANFORD SYMP.55     A.D.LIBERMAN                       (STANFORD)
MARTIN   75 PRL 34 288           +BOLON,DAKIN,FELDMAN,HANSON+(MIT+MASA+SLAC)
PREPOST  75 STANFORD SYMP.241 R.PREPOST                            (WISCONSIN)
SIMPSON  75 PRL 35 699           +BERON,FORD,HILGER,HOFSTADTER,+ (STAN+PENN)
WIIK     75 STANFORD SYMP.69     B.H.WIIK                               (DESY)
YENNIE   75 PRL 34 239           D.R.YENNIE                          (CORNELL)

ANTIPOV  76 TBILISI CONF.N 8     +BESSUBOV,BUDANOV,BUSHNIN,DENISOV,+   (SERP)
BACCI    76  LNF-76/60(P)        +BALDINI-CELIO,CAPON+      (FRAS+ROMA+GENO)
BARTEL 1 76 PL 64 B 483          +DUINKER,OLSSON,STEFFEN,HEINTZE+(DESY+HEID)
BRAUNSCH 76 PL 63 B 487          BRAUNSCHWEIG,+   (AACH+DESY+HAMB+MPIM+TOKY)
BUSSER   76 NP B 113 189         +BLUMENFELD,BANNER,+  (CERN+COLU+ROCK+SACL)
JEAN-MAR 76 PRL 36 291           +ABRAMS,BOYARSKI,BREIDENBACH,+   (SLAC+LBL)IG
PIERRE   76 SACLAY-DPHPE76-21 F.PIERRE                              (SLAC+LBL)
SNYDER   76 PRL 36 1415          +HOM,LEDERMAN,APPEL,KAPLAN+(COLU+FNAL+STON)

BARTEL   77 PL 66 B 489          +DUINKER,OLSSCN,HEINTZE,+         (DESY+HEID)
BIDDICK  77 PRL 38 1324          +BURNETT+     (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
BRAUNSCH 77  DESY 77/02          BRAUNSCHWEIG,+   (AACH+DESY+HAMB+MPIM+TOKY)
BURMESTE 77 PL 72 B 135          BURMESTER,CRIEGEE,+   (DESY+HAMB+SIEG+WUPP)
CORDEN   77 PL 68 B 96           +DOWELL,+    (BIRM+CERN+MPIM+NEUC+EPOL+RHEL)
FELDMAN  77 PL 33 C 285          +PERL                              (LBL+SLAC)
VANNUCCI 77 PR D 15 1814         +ABRAMS,ALAM,BOYARSKI,+            (SLAC+LBL)
YAMADA   77 HAMB. CONF. P. 69 YAMADA                              (DESY+TOKY)

ALEXANDE 78 PL 72 B 493          ALEXANDER,CRIEGEE,+   (DESY+HAMB+SIEG+WUPP)
BESCH    78 PL 78 B 347          +EISERMANN,KOWALSKI,V EYSS+(BONN+DESY+MANZ)
BRANDELI 78 PL 74 B 292          BRANDELIK,CORDS+ (AACH+DESY+HAMB+MPIM+TCKY)
PERUZZI  78 PR D 17 2901         +PICCOLO,ALAM,BOYARSKI,GOLDHABER+(SLAC+LBL)

BARATE   79  PREP. DPHPE 79-17+BAREYRE,BONAMI,+        (SACL+LCIC+SHMP+IND)
BRANDELI 79 ZPHY C 1 233         BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
KIRK     79 PRL 42 619           +GOODMAN,ALVERSON,+(FNAL+HARV+ILL+OXF+TUFT)
PARTRIDG 79  SLAC-PUB 2430       PARTRIDGE,PECK,+  (CIT+HARV+PRIN+SLAC+STAN)
   ALSO SLAC-PUB 2425            PARTRIDGE,PECK,+  (CIT+HARV+PRIN+SLAC+STAN)
SCHARRE  79  SLAC-PUB-2321       D.L. SCHARRE                       (SLAC+LBL)
   ALSO 79  LBL 9502              ABRAMS,ALAM,BLOCKER,BOYARSKI,+  (SLAC+LBL)
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χ(3415)

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56   CHI(3415,JPG=0++) I=0

          OBSERVED IN THE RADIATIVE DECAY OF PSI(3685) INTO
     CHI(3415) GAMMA. THEREFORE C=+. THE OBSERVED DECAY INTO PI+ PI-
     OR K+ K- IMPLIES G=+, JP=0+,2+,... . THE ANGULAR DISTRIBUTION
     IS CONSISTENT WITH J=0. JP ABNORMAL EXCLUDED BY PI+ PI- AND
     K+ K- DECAYS. JP=0+ PREFERRED (FELDMAN 77) .

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                    56  CHI(3415) MASS (MEV)

M    W   2 3412.0      8.0            WIIK      75 DASP   E+E-,J/PSI 2 GAM  1/77
M          3413.0      9.0            BIDDICK   77 CNTR   E+E-,MONOCHR.GAM  3/77
M     Z    3420.0     13.0            BARTEL    78 CNTR   E+E-,J/PSI 2 GAM  4/78*
M   W M    3414.0      7.0            TANENBAUM 78 SMAG   E+ E-            12/78*
M     M  FROM A SIMULTANEOUS FIT TO RADIATIVE AND HADRONIC DECAY CHANNELS
M   W    ERROR INCREASED 4 MEV TO CORRECT FOR ENERGY CALIBRATION
M     Z  ERROR INCREASED 3 MEV TO CORRECT FOR PSI(3685) MASS ERROR
M          . . . . . . . . .
M   AVG    3413.9      4.3       AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT3413.8      4.6       AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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               56  CHI(3415) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     CHI(3415) INTO PI+ PI-                                139+ 139
P2     CHI(3415) INTO K+ K-                                  493+ 493
P3     CHI(3415) INTO 2(PI+ PI-)                             139+ 139+ 139+ 139
P4     CHI(3415) INTO 3(PI+ PI-)
P5     CHI(3415) INTO PI+ PI- K+ K-                          139+ 139+ 493+ 493
P6     CHI(3415) INTO J/PSI(3100) GAMMA                     3097+   0
P7     CHI(3415) INTO 2 GAMMA                                  0+   0
P8     CHI(3415) INTO PI+ PI- P PBAR                         139+ 139+ 938+ 938
P9     CHI(3415) INTO RHO0 PI+ PI-                           776+ 139+ 139
P10    CHI(3415) INTO K*(892)0 K+/- PI-/+                    892+ 493+ 139
P11    CHI(3415) INTO P PBAR                                 938+ 938

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               56  CHI(3415) BRANCHING RATIOS

R1     CHI(3415) INTO (2 GAMMA)/TOTAL
R1 T        (0.0018)OR LESS  CL=0.90 YAMADA    77 DASP    E+ E-,3 GAMMA    12/77

R2     CHI(3415) INTO 2(PI+ PI-)/TOTAL
R2 T          .046      .009          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78*

R3     CHI(3415) INTO (PI+ PI- K+ K-)/TOTAL
R3 T          .037      .009          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78*

R4     CHI(3415) INTO 3(PI+ PI-)/TOTAL
R4 T          .019      .007          FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77

R5     CHI(3415) INTO (PI+ PI-)/TOTAL
R5 T          .01       .003          FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77
R5 T         0.008     0.003          BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79*
R5          . . . . . . . . .
R5   AVG     0.0090    0.0021   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5   STUDENT 0.0090    0.0023   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R6     CHI(3415) INTO (K+ K-)/TOTAL
R6 T          .01       .003          FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77
R6 T         0.007     0.003          BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79*
R6          . . . . . . . . .
R6   AVG     0.0085    0.0021   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6   STUDENT 0.0085    0.0023   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R7     CHI(3415) INTO (PI+ PI- P PBAR)/TOTAL
R7 T          .006      .002          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78*

R8     CHI(3415) INTO (J/PSI(3100) GAMMA)/TOTAL
R8 T         0.042     0.022          BIDDICK   77 CNTR PSI(3685)TO GAM CHI 12/77
R8 T         0.03      0.03           FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77
R8 T         0.019     0.012          BARTEL    78 CNTR PSI(3685)TO GAM CHI  4/78*
R8 T         0.042     0.028          BRANDEL1  79 DASP PSI(3685)TO GAM CHI 12/79*
R8 T    29  (0.007)OR LESS CL=0.90    PARTRIDGE 79 CNTR PSI(3685)TO GAM CHI 12/79*
R8          . . . . . . . . .
R8   AVG     0.0268    0.0094   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8   STUDENT 0.027     0.010    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R9     CHI(3415) INTO (RHO0 PI+ PI-)/TOTAL
R9 T          .018      .006          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78*

R10    CHI(3415) INTO (K*(892)0 K+ - PI- +)/TOTAL
R10T          .015      .005          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78*

R11    CHI(3415) INTO (P PBAR)/TOTAL (UNITS 10**-4)
R11T        (0.95) OR LESS  CL=0.90   BRANDEL1  79 DASP PSI(3685)TO GAM CHI 12/79*

R  T    CALCULATED USING PSI(3685) TO (GAMMA CHI(3415))/TOTAL=.075
R  T    THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.

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REFERENCES FOR CHI(3415)


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FELDMAN  75 PRL 35 821           +JEAN-MARIE,SADOULET,VANNUCCI,+  (LBL+SLAC)
   ALSO  75 PRL 35 1189  (ERRATA)
TANENBAU 75 PRL 35 1323          TANENBAUM,WHITAKER,ABRAMS,+        (LBL+SLAC)
WIIK     75 STANFORD SYMP.69     B.H.WIIK                               (DESY)

BIDDICK  77 PRL 38 1324          +BURNETT+     (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
FELDMAN  77 PL 33 C 285          +PERL                              (LBL+SLAC)
YAMADA   77 HAMB. CONF. P. 69 YAMADA                              (DESY+TOKY)

BARTEL   78 PL 79 B 492          DITTMANN,DUINKER,OLSSON,O+NEILL+(DESY+HEID)
TANENBAU 78 PR D 17 1731         TANENBAUN,ALAM,BOYARSKI,+          (SLAC+LBL)

BRANDEL1 79 ZPHY C 1 233         BRANDELIK,CCRDS,+(AACH+CESY+HAMB+MPIM+TCKY)
BRANDEL2 79 NP B 160 426         BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TCKY)
KIRK     79 PRL 42 619           +GOODMAN,ALVERSON,+(FNAL+HARV+ILL+OXF+TUFT)
PARTRIDG 79  SLAC-PUB 2425       PARTRIDGE,PECK,+  (CIT+HARV+PRIN+SLAC+STAN)
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χ(3455)

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58   CHI(3455,JPG=    ) I=

          OBSERVED IN THE CASCADE RADIATIVE DECAY OF PSI(3685)
          INTO CHI(3455) GAMMA, CHI(3455) INTO J/PSI(3100) GAMMA
          (WHITAKER 76), THEREFORE C=+.  NOT SEEN IN HADRONIC
     MODES. NOT SEEN IN OTHER EXPERIMENTS LOOKING CNLY FOR MONOCHRCMATIC
     PHOTONS (BARTEL 78). NOT SEEN BY THE CRYSTAL BALL (PARTRIDGE 79)
     WITH SUPERIOR STATISTICS. OMITTED FROM TABLE.

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REFERENCES FOR CHI(3455)


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WHITAKER 76 PRL 37 1596          +TANENBAUM,ABRAMS,ALAM,BOYARSKI,+(SLAC+LBL)
WIIK     76 TBILISI CONF.N75     B.H.WIIK RAPPORTEUR                    (DESY)
BARTEL   78 PL 79 B 492          +DITTMANN,DUINKER,OLSSON,ONEILL+(DESY+HEID)
PARTRIDG 79  SLAC-PUB 2425       PARTRIDGE,PECK,+  (CIT+HARV+PRIN+SLAC+STAN)
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P_c or χ(3510)

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55   PC OR CHI(3510,JPG=  +) I=0

          OBSERVED IN THE RADIATIVE SEQUENTIAL DECAY
          OF THE PSI(3685) INTO PC GAMMA, PC INTO
          J/PSI(3100) GAMMA. THEREFORE, C=+.
     THE LACK OF DECAYS INTO PI+ PI- OR K+ K- IS SUGGESTIVE OF
     JP = ABNORMAL. THE DECAYS INTO 4PI AND 6PI IMPLY G=+, THUS I=0.
     J=0 IS EXCLUDED BY THE ANGULAR DISTRIBUTION IN THE (GAMMA J/PSI)
     DECAY. JP=1+ PREFERRED (FELDMAN 77) .
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Mesons

P_c or $\chi(3510)$, $\chi(3550)$

Data Card Listings

For notation, see key at front of Listings.

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                       55  PC MASS (MEV)

M        40(3500.)    (10.)          TANENBAUM 75 SMAG        HADRONS GAM 12/77
M    W    7(3512.0)    (7.0)         WIIK      75 DASP   E+E-,J/PSI 2 GAM  1/77
M          (3510.0)   (20.0)         BARTEL    76 CNTR   E+E-,J/PSI 2 GAM  1/77
M           3511.0      7.0          BIDDICK   77 CNTR   E+E-,MONOCHR.GAM  3/77
M    Z      3505.0      6.0          BARTEL    78 CNTR   E+E-,J/PSI 2 GAM  4/78*
M   W M     3503.0      8.0          TANENBAUN 78 SMAG   E+ E-            12/78*
M   W    21 3509.0     11.0          BRANDEL2  79 DASP   E+E-,J/PSI 2GAM  12/79*
M        15(3520.)                   LEMOIGNE  79 SPEC  0 150 PI-BE,2MU   12/79*
M           . . . . . . . . .
M   AVG     3506.7      3.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT3506.7       4.1     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M    M  FROM A SIMULTANEOUS FIT TO RADIATIVE AND HADRONIC DECAY CHANNELS
M   W   INCREASED 4 MEV TO CORRECT FOR ENERGY CALIBRATION
M    Z  ERROR INCREASED 3 MEV TO CORRECT FOR PSI(3685) MASS ERROR

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                       55  PC PARTIAL DECAY MODES

                                                       DECAY MASSES
P1      PC INTO J/PSI(3100) GAMMA                     3097+    0
P2      PC INTO PI+ PI-                                139+  139
P3      PC INTO K+ K-                                  493+  493
P4      PC INTO GAMMA GAMMA                              0+    0
P5      PC INTO 2(PI+ PI-)                             139+  139+  139+  139
P6      PC INTO 3(PI+ PI-)
P7      PC INTO PI+ PI- K+ K-                          139+  139+  493+  493
P8      PC INTO PI+ PI- P PBAR                         139+  139+  938+  938
P9      PC INTO RHOO PI+ PI-                           776+  139+  139
P10     PC INTO K*(892)0 K+/- PI-/+                    892+  493+  139
P11     PC INTO PI+ PI- X(2830)
P12     PC INTO P PBAR                                 938+  938

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                       55  PC BRANCHING RATIOS

R1      PC INTO (J/PSI(3100) GAMMA)/TOTAL
R1 T        0.70      0.21        BIDDICK   77 CNTR PSI(3685)TO GAM  PC 12/77
R1 T        0.35      0.06        BARTEL    78 CNTR PSI(3685)TO GAM  PC  4/78*
R1 T        0.34      0.11        TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78*
R1 T        0.24      0.06        BRANDEL1  79 DASP PSI(3685)TO GAM CHI 12/79*
R1 T  1027 (0.29)    (0.05)       PARTRIDGE 79 CNTR PSI(3685) TO GAM PC 12/79*
R1          . . . . . . . . .
R1   AVG    0.315     0.052   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R1   STUDENT 0.315    0.046   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                              (SEE IDEOGRAM BELOW )
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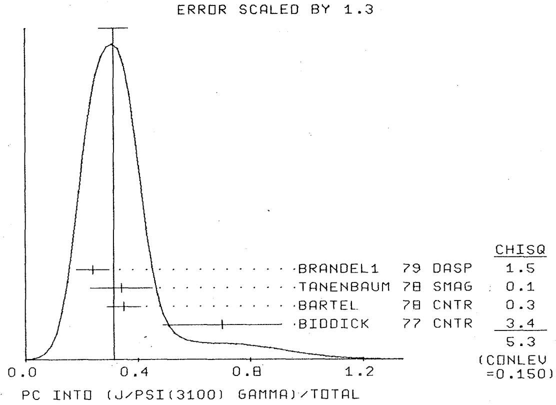
WEIGHTED AVERAGE = 0.315 ± 0.052
ERROR SCALED BY 1.3

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R2      PC INTO (PI+PI- AND K+K-)/TOTAL
R2 T        (0.0021)OR LESS           FELDMAN   77 SMAG PSI(3685) TO GAM PC 12/77
R2 T        (0.0046)OR LESS CL=0.90   BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79*

R3      PC INTO (GAMMA GAMMA)/TOTAL
R3 T        (0.0019)OR LESS CL=0.90   YAMADA    77 DASP   E+ E-,3 GAMMA     12/77

R4      PC INTO 2(PI+ PI-)/TOTAL
R4 T          .020      .006          TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78*

R5      PC INTO (PI+ PI- K+ K-)/TOTAL
R5 T          .011      .004          TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78*

R6      PC INTO 3(PI+ PI-)/TOTAL
R6 T          .027      .011          TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78*

R7      PC INTO (PI+ PI- P PBAR)/TOTAL
R7 T          .0017     .0011         TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78*

R8      PC INTO (RHOO PI+ PI-)/TOTAL
R8 T          .0048     .0040         TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78*

R9      PC INTO (K*(892)0 K+ - PI- +)/TOTAL
R9 T          .0038     .0024         TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78*

R11     PC INTO (P PBAR)/TOTAL
R11 T       (0.0014)OR LESS CL=0.90   BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79*

R  C    THE VALUE IS NORMALIZED TO THE BRANCHI. RATIO O PSI(3685)
R  C    INTO (J/PSI(3100) ETA)/TOTAL.
R  T    ESTIMATED USING PSI(3685) TO (GAMMA PC)/TOTAL=.071                    12/77
R  T    THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.

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                              REFERENCES FOR PC

DASP      75 PL 57B 407          BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
FELDMAN   75 STANFORD SYMP.39    G.J.FELDMAN                            (SLAC)
HEINTZE   75 STANFORD SYMP.97    J.HEINTZE                        (HEIDELBERG)
SIMPSON   75 PRL 35 699          +BERON,FORD,HILGER,HOFSTADTER,+ (STAN+PENN)
TANENBAU  75 PRL 35 1323         TANENBAUM,WHITAKER,ABRAMS,+        (LBL+SLAC)
WIIK      75 STANFORD SYMP.69    B.H.WIIK                               (DESY)

BARTEL    76 TBILISI CONF.N75    +DUINKER,OLSSON,HEINTZE,+         (DESY+HEID)

BARTEL    77  DESY 77/70         +DITTMANN,FRITSCHER,HEINTZE,+     (DESY+HEID)
BIDDICK   77 PRL 38 1324         +BURNETT+      (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
FELDMAN   77 PL 33 C 285         +PERL                              (LBL+SLAC)
YAMADA    77 HAMB. CONF. P. 69   YAMADA                            (DESY+TOKY)

BARTEL    78 PL 79 B 492         +DITTMANN,DUINKER,OLSSON,ONEILL+(DESY+HEID)
TANENBAU  78 PR D 17 1731        TANENBAUN,ALAM,BOYARSKI,+          (SLAC+LBL)

BRANDEL1  79 ZPHY C 1 233        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TCKY)
BRANDEL2  79 NP B 160 426        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
KIRK      79 PRL 42 619          +GOODMAN,ALVERSON,+(FNAL+HARV+ILL+CXF+TUFT)
LEMOIGNE  79  D PH PE 79-16      +ABOLINS,BARATE,+       (SACL+LOIC+SHMP+IND)
PARTRIDG  79  SLAC-PUB 2425      PARTRIDGE,PECK,+  (CIT+HARV+PRIN+SLAC+STAN)
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$\chi(3550)$

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 57  CHI(3550,JPG=  +) I=0

            OBSERVED IN RADIATIVE DECAY OF PSI(3685) INTO
      CHI(3550) GAMMA. THEREFORE C=+. THE OBSERVED DECAY INTO 4PI
      AND 6PI IMPLY G=+, THUS I=0.
      J=0 IS EXCLUDED BY THE ANGULAR DISTRIBUTION IN THE HADRONIC
      DECAYS. JP ABNORMAL EXCLUDED BY PI+ PI- AND K+ K- DECAYS.
      JP=2+ PREFERRED (FELDMAN 77) .

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                       57  CHI(3550) MASS (MEV)

M          (3550.0)    (10.0)          TRILLING  76 SMAG   E+E-,HADRONS GAM  1/77
M         4(3543.0)    (10.0)          WHITAKER  76 SMAG   E+E-,J/PSI 2 GAM  1/77
M          (3561.0)     (7.0)          BIDDICK   77 CNTR   E+E-,MONOCHR.GAM  3/77
M     Z     3551.0       7.0           BARTEL    78 CNTR   E+E-,J/PSI 2 GAM  4/78*
M    W M    3551.0       8.0           TANENBAUM 78 SMAG   E+ E-            12/78*
M        15 3551.0      11.0           BRANDEL2  79 DASP   E+E-,J/PSI 2GAM  12/79*
M           . . . . . . . . .
M   AVG     3551.0       4.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT3551.0        5.1      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M     M  FROM A SIMULTANEOUS FIT TO RADIATIVE AND HADRONIC DECAY CHANNELS
M    W   INCREASED 4 MEV TO CORRECT FOR ENERGY CALIBRATION
M     Z  ERROR INCREASED 3 MEV TO CORRECT FOR PSI(3685) MASS ERROR

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                       57  CHI(3550) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      CHI(3550) INTO PI+ PI-                            139+  139
P2      CHI(3550) INTO K+ K-                              493+  493
P3      CHI(3550) INTO 2(PI+ PI-)                         139+  139+  139+  139
P4      CHI(3550) INTO 3(PI+ PI-)
P5      CHI(3550) INTO PI+ PI- K+ K-                      139+  139+  493+  493
P6      CHI(3550) INTO J/PSI(3100) GAMMA                 3097+    0
P7      CHI(3550) INTO 2 GAMMA                              0+    0
P8      CHI(3550) INTO PI+ PI- P PBAR                     139+  139+  938+  938
P9      CHI(3550) INTO RHOO PI+ PI-                       776+  139+  139
P10     CHI(3550) INTO K*(892)0 K+/- PI-/+                892+  493+  139
P11     CHI(3550) INTO P PBAR                             938+  938

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                       57  CHI(3550) BRANCHING RATIOS

R1      CHI(3550) INTO (2 GAMMA)/TOTAL
R1 T          (0.0006)OR LESS  CL=0.90 YAMADA    77 DASP    E+ E-,3 GAMMA      12/77

R2      CHI(3550) INTO 2(PI+ PI-)/TOTAL
R2 T          .024      .006          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78*

R3      CHI(3550) INTO (PI+ PI- K+ K-)/TOTAL
R3 T          .021      .006          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78*

R4      CHI(3550) INTO 3(PI+ PI-)/TOTAL
R4 T          .013      .008          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78*

R5      CHI(3550) INTO (PI+ PI- AND K+ K-)/TOTAL
R5 T          .0027     .0011         TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78*

R6      CHI(3550) INTO (PI+ PI- P PBAR)/TOTAL
R6 T          .0037     .0014         TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78*

R7      CHI(3550) INTO (J/PSI(3100) GAMMA)/TOTAL
R7 T        0.31      0.14            BIDDICK   77 CNTR PSI(3685)TO GAM CHI 12/77
R7 T        0.14      0.03            BARTEL    78 CNTR PSI(3685)TO GAM CHI  4/78*
R7 T        0.13      0.14      0.07  SPITZER   78 PLUT PSI(3685)TO GAM CHI 12/78*
R7 T         .14       .08            TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78*
R7 T        0.20      0.06            BRANDEL1  79 DASP PSI(3685)TO GAM CHI 12/79*
R7 T   531 (0.16)    (0.04)           PARTRIDGE 79 CNTR PSI(3685)TO GAM CHI 12/79*
R7          . . . . . . . . .
R7   AVG    0.154     0.024     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R7   STUDENT 0.154    0.027     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R8      CHI(3550) INTO (RHOO PI+ PI-)/TOTAL
R8 T          .0074     .0042         TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78*

R9      CHI(3550) INTO (K*(892)0 K+ - PI- +)/TOTAL
R9 T          .0052     .0031         TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78*

R10     CHI(3550) INTO (PI+ PI-)/TOTAL (UNITS 10**-3)     (P1)
R10T      4   2.1       1.1           BRANDEL1  79 DASP PSI(3685)TO GAM CHI 12/79*

R11     CHI(3550) INTO (K+ K-)/TOTAL (UNITS 10**-3)       (P2)
R11T      2   1.7       1.3           BRANDEL1  79 DASP PSI(3685)TO GAM CHI 12/79*

R12     CHI(3550) INTO (P PBAR)/TOTAL (UNITS 10**-3)      (P11)
R12T          (1.1)  OR LESS CL=0.90  BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79*

R  T    ESTIMATED USING PSI(3685) TO (GAMMA CHI(3550))/TOTAL=.07
R  T    THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.

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Data Card Listings

For notation, see key at front of Listings.

Mesons

χ(3550), χ(3590), ψ(3685)


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                          REFERENCES FOR CHI(3550)

FELDMAN  75 PRL 35 821          +JEAN-MARIE,SADOULET,VANNUCCI,+  (LBL+SLAC)
  ALSO   75 PRL 35 1189  (ERRATA)
TANENBAU 75 PRL 35 1323         TANENBAUM,WHITAKER,ABRAMS,+      (LBL+SLAC)

TRILLING 76 STANFORD SYMP.437 G. H. TRILLING                        (LBL)
WHITAKER 76 PRL 37 1596         +TANENBAUM,ABRAMS,ALAM,BOYARSKI,+(SLAC+LBL)

BIDDICK  77 PRL 38 1324         +BURNETT+    (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
FELDMAN  77 PL 33 C 285         +PERL                            (LBL+SLAC)
YAMADA   77 HAMB. CONF. P. 69 YAMADA                           (DESY+TOKY)

BARTEL   78 PL 79 B 492         DITTMANN,DUINKER,OLSSON,O+NEILL+(DESY+HEID)
SPITZER  78 KYOTO SUM.INST.47 H. SPITZER                           (HAMB)
TANENBAU 78 PR D 17 1731        TANENBAUN,ALAM,BOYARSKI,+        (SLAC+LBL)

BRANDEL1 79 ZPHY C 1 233        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
BRANDEL2 79 NP B 160 426        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
KIRK     79 PRL 42 619          +GOODMAN,ALVERSON,+(FNAL+HARV+ILL+OXF+TUFT)
PARTRIDG 79  SLAC-PUB 2425      PARTRIDGE,PECK,+  (CIT+HARV+PRIN+SLAC+STAN)

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χ(3590) →

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59  CHI(3590,JPG=    ) I=

OBSERVED IN THE CASCADE RADIATIVE DECAY OF PSI(3685)
INTO CHI(3590) GAMMA,CHI(3590) INTO J/PSI(3100) GAMMA
(BARTEL 78).THEREFORE,C=+.
NOT SEEN BY THE CRYSTAL BALL VITH LARGER
STATISTICS ( PARTIDGE 79).
OMITTED FROM TABLE.

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                  59  CHI(3590) MASS (MEV)

M        3591.0     7.0          BARTEL    78 CNTR    E+E-,J/PSI 2 GAM  4/78*

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                          REFERENCES FOR CHI(3590)

BARTEL   78 PL 79 B 492         +DITTMANN,DUINKER,OLSSON,ONEILL+(DESY+HEID)
PARTRIDG 79  SLAC-PUB 2425      PARTRIDGE,PECK,+  (CIT+HARV+PRIN+SLAC+STAN)

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ψ(3685)

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71  PSI(3685,JPG=1--) I=0
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                  71  PSI(3685) MASS (MEV)

                  WE USE INDEPENDENT MEASUREMENTS OF THE J/PSI(3100)
                  MASS, THE PSI(3685) MASS, AND THE MASS DIFFERENCE TO
                  PERFORM A CONSTRAINED FIT.

M  S       3680.3      37.          CRIEGEE   75 PLUT        E+E-         2/75
M          3684.       5.           LUTH      75 SMAG        E+E-         1/76
M          3684.       9.           PREPOST   75 SPEC    21. GAMMA D      1/76
M   J   280(3682.0)   (2.0)         BARATE    79 SPEC  0 150 PI-BE,2MU2PI 12/79*
M       140(3683.0)   (6.0)         BARATE    79 SPEC  0 150 PI-BE,2MU    12/79*
M  F       3686.       3.           BRANDEL1  79 DASP    E+ E-            12/79*
M          . . . . . . . . . .
M   AVG    3685.3      2.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT3685.3      2.7     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M   FIT    3685.3      1.2    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

M   J   USING J/PSI(3100) MASS=3097.0 MEV.
M   F   FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
M   F   ASSUMING G(E+ E-) = G(MU+ MU-)
M   S   ERROR OF ABOUT 1 PER CENT FROM THE UNCERTAINTY IN CALIBRATION OF
M   S   THE BEAM ENERGY.

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                  71  PSI(3685) - J/PSI(3100) MASS DIFFERENCE (MEV)

DM          588.7       .8          LUTH      75 SMAG                     1/76
DM          585.0      2.0          BARATE    79 SPEC  0 150 PI-BE,2MU    12/79*
DM          . . . . . . . . . .
DM  AVG     588.2      1.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
DM  STUDENT 588.26     0.86    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
DM  FIT     588.2      0.9    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

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                  71  PSI(3685) WIDTH (KEV)

W           228.       56.          LUTH      75 SMAG
W   F       202.       57.          BRANDEL1  79 DASP    E+ E-            12/79*
W   F   FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
W   F   ASSUMING G(E+ E-) = G(MU+ MU-)
W           . . . . . . . . . .
W   AVG     215.2      39.9    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W   STUDENT 215.2      43.0    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                  71  PSI(3685) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     PSI(3685) INTO E+ E-                              .5+  .5
P2     PSI(3685) INTO MU+ MU-                           105+ 105
P3     PSI(3685) INTO HADRONS
P4     PSI(3685) INTO VIRTUAL GAMMA INTO HADRONS
P5     PSI(3685) INTO GAMMA GAMMA                         0+   0

P      DECAYS INTO J/PSI(3100) + ANYTHING
P      --------------------------------
P11    PSI(3685) INTO J/PSI(3100) + ANYTHING
P12    PSI(3685) INTO J/PSI(3100) + NEUTRALS
P13    PSI(3685) INTO J/PSI(3100) PI+ PI-               3097+ 139+ 139
P14    PSI(3685) INTO J/PSI(3100) PIO PIO               3097+ 134+ 134
P15    PSI(3685) INTO J/PSI(3100) ETA                   3097+ 548
P16    PSI(3685) INTO J/PSI(3100) GAMMA GAMMA           3686+   0+   0

P      HADRONIC DECAYS
P      ---------------
P21    PSI(3685) INTO PI+ PI-                            139+ 139
P22    PSI(3685) INTO RHO PI                             776+ 139
P23    PSI(3685) INTO K+ K-                              493+ 493
P24    PSI(3685) INTO 2(PI+ PI-)                         139+ 139+ 139+ 139
P25    PSI(3685) INTO 2(PI+ PI-) PIO                     139+ 139+ 139+ 139+
P26    PSI(3685) INTO PI+ PI- K+ K-                      139+ 139+ 493+ 493
P27    PSI(3685) INTO PBAR P                             938+ 938
P28    PSI(3685) INTO LAMBDA ANTILAMBDA                 1115+1115
P29    PSI(3685) INTO XI ANTIXI                         1321+1321
P30    PSI(3685) INTO OMEGA X(2830)                      782+2830
P31    PSI(3685) INTO PI+ PI- P PBAR                     139+ 139+ 938+ 938
P32    PSI(3685) INTO  3(PI+ PI-)
P33    PSI(3685) INTO RHO0 PI+ PI-                       776+ 139+ 139
P34    PSI(3685) INTO K*(890)0 K+/- PI-/+                892+ 493+ 139

P      RADIATIVE DECAYS
P      ----------------
P51    PSI(3685) INTO GAMMA GAMMA                          0+   0
P52    PSI(3685) INTO PIO GAMMA                          134+   0
P53    PSI(3685) INTO ETA GAMMA                          548+   0
P54    PSI(3685) INTO ETA PRIME GAMMA                    957+   0
P55    PSI(3685) INTO X(2830) GAMMA                     2830+   0
P56    PSI(3685) INTO CHI(3415) GAMMA                   3414+   0
P57    PSI(3685) INTO CHI(3455) GAMMA                   3454+   0
P58    PSI(3685) INTO PC(3510) GAMMA                    3507+   0
P59    PSI(3685) INTO CHI(3550) GAMMA                   3551+   0
P60    PSI(3685) INTO PC(3510) + ANYTHING
P61    PSI(3685) INTO U(2980) GAMMA                     2980+   0

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	$J/\psi\ \pi^+\pi^-$	$J/\psi\ \pi^0\pi^0$	$J/\psi\ \eta$	J/ψ+OTHER	NON-J/ψ
$J/\psi\ \pi^+\pi^-$	.3251+-.0238				
$J/\psi\ \pi^0\pi^0$	.4600	.1722+-.0176			
$J/\psi\ \eta$	-.0157	-.0072	.0374+-.0038		
J/ψ+OTHER	.2111	-.4624	-.0883	.0333+-.0248	
NON-J/ψ	-.8950	-.4117	-.0276	-.5150	.4320+-.0415

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                  71  PSI(3685) PARTIAL WIDTHS (KEV)

W1     PSI(3685) INTO E+ E-                                 (G1)
W1           2.1        .3          LUTH      75 SMAG        E+E-         1/76
W1 F         2.        0.3          BRANDEL1  79 DASP    E+ E-            12/79*
W1 F    FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
W1 F    ASSUMING G(E+ E-) = G(MU+ MU-)
W1          . . . . . . . . . .
W1  AVG      2.05      0.21    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W1  STUDENT  2.05      0.23    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W3     PSI(3685) INTO HADRONS                               (G3)
W3          224.       56.          LUTH      75 SMAG        E+E-         1/76

W5     PSI(3685) INTO GAMMA GAMMA    (EV)                   (G4)
W5          43. OR LESS CL=0.90     BRANDEL1  79 DASP    E+ E-            12/79*

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                  71  PSI(3685) BRANCHING RATIOS

R1     PSI(3685) INTO (E+ E-)/TOTAL
R1 L        .0088      .0013        FELDMAN   77 RVUE        E+E-         12/77
R1 L    FROM AN OVERALL FIT ASSUMING EQUAL PARTIAL WIDTHS FOR (E+E-)
R1 L    AND (MU+MU-). FOR A MEASUREMENT OF THE RATIO SEE THE ENTRY R4 BELOW
R1 L    INCLUDES LUTH 75,HILGER 75,BURMESTER 77

R2     PSI(3685) INTO (MU+ MU-)/TOTAL
R2 H        .0077      .0017        HILGER    75 SPEC        E+E-         1/76
R2 H    RE-STATED BY US USING (J/PSI(3100)+ANYTHING)/TOTAL =0.55

R3     PSI(3685) INTO (HADRONS)/TOTAL
R3   P      .981       .003         LUTH      75 SMAG        E+E-         1/76
R3   P  INCLUDES CASCADE DECAY INTO J/PSI(3100)                           4/77

R4     PSI(3685) INTO (MU+ MU-)/(E+ E-)
R4          .89        .16          BOYARSKI  75 SMAG        E+E-         12/77

R5     PSI(3685) INTO (GAMMA INTO HADRONS)/TOTAL
R5 C        .029       .004         LUTH      75 SMAG        E+E-         1/76
R5 C    INCLUDED IN R3


R      DECAYS INTO J/PSI(3100) + ANYTHING
R      --------------------------------

R10    PSI(3685) INTO (J/PSI(3100) + ANYTHING)/TOTAL
R10         .57        .08          ABRAMS    75 SMAG        E+E-         1/76
R10         0.51       0.12         BRANDEL1  79 DASP    E+ E-            12/79*
R10         . . . . . . . . . .
R10 AVG     0.552      0.067   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R10 STUDENT 0.552      0.072   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R10 FIT     0.568      0.041  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R11    PSI(3685) INTO (J/PSI(3100) + NEUTRALS)/(J/PSI(3100) + ANYTHING)
R11         .41        .02          TANENBAUM 76 SMAG        E+E-         2/76
R11         . . . . . . . . . .
R11 FIT     0.409      0.019  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R12    PSI(3685) INTO (J/PSI(3100) PI+ PI-)/TOTAL
R12         .32        .04          ABRAMS1   75 SMAG        E+E-         1/76
R12         .36        .06          WIIK      75 DASP        E+E-         1/76
R12         . . . . . . . . . .
R12 AVG     0.332      0.033   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R12 STUDENT 0.332      0.036   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R12 FIT     0.325      0.024  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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Mesons
ψ(3685), ψ(3770)

Data Card Listings
For notation, see key at front of Listings.

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R13    PSI(3685) INTO (J/PSI(3100) PIO PIO)/TOTAL
R13          0.17      0.029          ABRAMS1    75 SMAG          E+E-          1/77
R13          .18       .06            WIIK       75 DASP          E+E-          1/76
R13          . . . . . . . . .
R13 AVG      0.172     0.026    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R13 STUDENT  0.172     0.028    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R13 FIT      0.172     0.018   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R14    PSI(3685) INTO (J/PSI(3100) PIO PIO)/(J/PSI(3100) PI+ PI-)
R14 H        (.64)     (.15)          HILGER     75 SPEC          E+E-          1/76
R14          0.53      0.06           TANENBAUM 76 SMAG           E+E-          1/77
R14 H   IGNORING THE (J/PSI ETA) AND (J/PSI GAMMA GAMMA) DECAYS
R14          . . . . . . . . .
R14 FIT      0.530     0.050   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R15    PSI(3685) INTO (J/PSI(3100) ETA)/TOTAL
R15          .043      .008           TANENBAUM 76 SMAG           E+E-          1/76
R15    164   0.036     0.005          BARTEL     78 CNTR     E+E-               4/78*
R15          0.035     0.009          BRANDEL2   79 DASP PSI(3685)TO GAM CHI 12/79*
R15          . . . . . . . . .
R15 AVG      0.0374    0.0038   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R15 STUDENT  0.0374    0.0042   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R15 FIT      0.0374    0.0038  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R16    PSI(3685) INTO (J/PSI(3100) GAMMA OR J/PSI(3100) PIO)/TOTAL
R16          (.0015)OR LESS CL=.90    TANENBAUM 76 SMAG           E+E-          2/76
R16          (0.001)OR LESS CL=.90    BARTEL     78 CNTR     E+E-               4/78*
R16          (0.004)OR LESS CL=0.90   BRANDEL1   79 DASP     E+ E-             12/79*


R      HADRONIC DECAYS
R      ---------------

R20    PSI(3685) INTO (PI+ PI-)/TOTAL  (UNITS 10**-4)
R20          (0.5)  OR LESS  CL=0.90  FELDMAN    77 SMAG          E+E-         12/77
R20          0.8       0.5            BRANDEL1   79 DASP     E+ E-             12/79*

R21    PSI(3685) INTO (RHOO PIO)/TOTAL
R21          (.001)OR LESS  CL=.90    ABRAMS     75 SMAG          E+E-          1/76

R22    PSI(3685) INTO (2(PI+ PI-) PIO)/TOTAL
R22          .0035     .0015          ABRAMS     75 SMAG          E+E-          1/76

R23    PSI(3685) INTO (K+ K-)/TOTAL  (UNITS 10**-4)
R23          (0.5)  OR LESS  CL=0.90  FELDMAN    77 SMAG          E+E-         12/77
R23          1.0       0.7            BRANDEL1   79 DASP     E+ E-             12/79*

R24    PSI(3685) INTO (PI+ PI- K+ K-)/TOTAL
R24S         0.0016    0.0004         TANENBAUM 78 SMAG           E+E-         12/78*
R24S    ASSUMING ENTIRELY STRONG DECAY                                         12/78*

R25    PSI(3685) INTO (PBAR P)/TOTAL  (UNITS 10**-4)
R25          2.3       0.7            FELDMAN    77 SMAG          E+E-         12/77
R25      4   1.4       0.8            BRANDEL1   79 DASP     E+ E-             12/79*
R25          . . . . . . . . .
R25 AVG      1.91      0.53     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R25 STUDENT  1.91      0.59     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R26    PSI(3685) INTO (RHO PI)/TOTAL
R26          (0.001)OR LESS  CL=0.90  BARTEL 1   76 CNTR          E+E-          1/77

R27    PSI(3685) INTO 2(PI+PI-)/TOTAL
R27          0.00045   0.0001         TANENBAUM 78 SMAG           E+E-         12/78*

R28    PSI(3685) INTO (LAMBDA ANTILAMBDA)/TOTAL
R28          (0.0004)OR LESS  CL=0.90 FELDMAN    77 SMAG          E+E-         12/77

R29    PSI(3685) INTO (XI- ANTIXI-)/TOTAL
R29          (0.0002)                 FELDMAN    77 SMAG          E+E-         12/77


R31    PSI(3685) INTO (PI+ PI- P PBAR)/TOTAL (UNITS 10**-3)
R31S         0.8       0.2            TANENBAUM 78 SMAG      E+ E-             12/78*
R31S    ASSUMING ENTIRELY STRONG DECAY

R32    PSI(3685) INTO  3(PI+ PI-)/TOTAL (UNITS 10**-3)
R32S         0.15      0.1            TANENBAUM 78 SMAG      E+ E-             12/78*

R33    PSI(3685) INTO (RHOO PI+ PI-)/TOTAL (UNITS 10**-3)
R33          0.42      0.15           TANENBAUM 78 SMAG      E+ E-             12/78*

R34    PSI(3685) INTO (K*(890)0 K+/- PI-/+)/TOTAL (UNITS 10**-3)
R34          0.67      0.25           TANENBAUM 78 SMAG      E+ E-             12/78*


R      RADIATIVE DECAYS
R      ----------------

R41    PSI(3685) INTO (GAMMA GAMMA)/TOTAL
R41  U       (.005)OR LESS  CL=.95    HUGHES     75 SPEC          E+E-          1/76

R42    PSI(3685) INTO (PIO GAMMA)/TOTAL
R42  U       (.007)OR LESS  CL=.95    HUGHES     75 SPEC          E+E-          1/76
R42          (.01) OR LESS  CL=.90    WIIK       75 DASP          E+E-          1/76

R43    PSI(3685) INTO (ETA GAMMA)/TOTAL (UNITS 10**-2)
R43  U       (1.8)  OR LESS  CL=.95   HUGHES     75 SPEC          E+E-          1/76
R43          (0.02)OR LESS  CL=0.90   YAMADA     77 DASP     E+ E-,3 GAMMA     12/77

R44    PSI(3685) INTO (ETA PRIME GAMMA)/TOTAL (UNITS 10**-2)
R44C         (0.023)OR LESS CL=0.90   BARTEL 2   76 CNTR          E+E-         12/77
R44  R       (0.6)  OR LESS CL=0.90   BRAUNSCHW 77 DASP           E+E-         12/77

R55    PSI(3685) INTO (CHI(3415) GAMMA)/TOTAL  (UNITS 10**-2)
R55  A       7.5       2.6            WHITAKER   76 SMAG          E+E-          1/77
R55  A       7.2       2.3            BIDDICK    77 CNTR     E+E-,MONOCHR.GAM  3/77
R55          (7.6)     (1.7)          PARTRID1   79 CNTR     E+E-,MONOCHR.GAM 12/79*
R55          . . . . . . . . .
R55 AVG      7.3       1.7      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R55 STUDENT  7.3       1.8      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R57    PSI(3685) INTO (CHI(3550) GAMMA)/TOTAL  (UNITS 10**-2)
R57         CHI(3550) INTO CHANNEL SPECIFIED IN COMMENTS                       12/78*
R57  B       7.0       2.0            BIDDICK    77 CNTR     E+E-,MONOCHR.GAM  3/77

R59    PSI(3685) INTO (PC(3510) GAMMA)/TOTAL  (UNITS 10**-2)
R59         PC(3510) INTO CHANNEL SPECIFIED IN COMMENTS                        12/78*
R59  B       7.1       1.9            BIDDICK    77 CNTR     E+E-,MONOCHR.GAM  3/77
R59          (7.5)     (1.7)          PARTRID1   79 CNTR     E+E-,MONOCHR.GAM 12/79*

R61    PSI(3685) INTO U(2980)/TOTAL (UNITS 10**-2)
R60              U(2980) INTO CHANNEL SPECIFIED IN COMMENTS.
R60          (0.2) TO  0.5            PARTRID2   79 CNTR     E+E-,MONOCHR.GAM 12/79*
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R63    PSI(3685) INTO (CHI(3590) GAMMA)/TOTAL (UNITS 10**-2)
R63               CHI(3590) INTO CHANNEL SPECIFIED IN COMMENTS
R63          0.18      0.06           BARTEL     78 CNTR CHI TO(J/PSI GAMMA)  4/78*
R63          (0.06)OR LESS            PARTRID2   79 CNTR CHI TO(J/PSI GAMMA  12/79*

R    A  ANGULAR DISTRIBUTION (1+COS**2) ASSUMED
R    B  VALID FOR ISOTROPIC DISTRIBUTION CF THE PHOTON
R  C    THE VALUE IS NORMALIZED TO THE BRANCHI. RATIO O PSI(3685)
R  C    INTO (J/PSI(3100) ETA)/TOTAL.
R    U  RE-STATED BY US USING (MU+MU-)/TOTAL = .0077
R    R  RE-STATED BY US USING TOTAL DECAY WIDTH 228 KEV.

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              71  PSI(3685)      G(I)*G(E+E-)/G(TOTAL)  (KEV)

      THIS COMBINATION OF A PARTIAL WIDTH WITH THE PARTIAL WIDTH
      INTO E+E- AND WITH THE TOTAL WIDTH IS OBTAINED FROM THE INTEGRATED
      CROSS-SECTION INTO CHANNEL(I) IN THE E+E- ANNIHILATICN.
      WE ONLY LIST DATA NOT HAVING BEEN USED TO DETERMINE THE PARTIAL
      WIDTH G(I) OR THE BRANCHING RATIO G(I)/TOTAL.


G3     G(HADRONIC)*G(E+E-)/G(TOTAL)
G3           2.2       .4             ABRAMS     75 SMAG          E+E-          1/76


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                         REFERENCES FOR PSI(3685)
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ABRAMS    74 PRL 33 1453          +BRIGGS,AUGUSTIN,BOYARSKI+        (LBL+SLAC)

ABRAMS    75 STANFORD SYMP.25   G.S.ABRAMS                              (LBL)
ABRAMS1   75 PRL 34 1181        +BRIGGS,CHINOWSKY,FRIEDBERG,+    (LBL+SLAC)
AUBERT    75 PRL 33 1624        +BECKER,BIGGS,BURGER,GLENN+       (MIT+BNL)
BOYARSKI  75 PALERMO CONF. 54   +BREIDENBACH,BULOS,ABRAMS,BRIGGS+(SLAC+LBL)
CAMERINI  75 PRL 35 483         +LEARNED,PREPOST,ASH,ANDERSON,+ (WISC+SLAC)
CRIEGEE   75 PL 53B 489         +DEHNE,FRANKE,HORLITZ,KRECHLOCK+     (DESY)
DASP3     75 PL 57B 407         BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
FELDMAN   75 PRL 35 821         +JEAN-MARIE,SADOULET,VANNUCCI,+  (LBL+SLAC)
GRECO     75 PL 56B 367         +PANCHERI-SRIVASTAVA,SRIVASTAVA      (FRAS)
JACKSON   75 NIM 128 13         J.D.JACKSON,D.SCHARRE                 (LBL)
HILGER    75 PRL 35 625         +BERON,FORD,HOFSTADTER,HOWELL,+ (STAN+PENN)
HUGHES    75   PREP.HEPL 765    +BERON,CARRINGTON,FORD,HILGER,+ (STAN+PENN)
LUTH      75 PRL 35 1124        +BOYARSKI,LYNCH,BREIDENBACH,+    (SLAC+LBL)JPC
PREPOST   75 STANFORD SYMP.241  R.PREPOST                         (WISCCNSIN)
SIMPSON   75 PRL 35 699         +BERON,FORD,HILGER,HOFSTADTER,+ (STAN+PENN)
WIIK      75 STANFORD SYMP.69   B.H.WIIK                             (DESY)

BARTEL 1  76 PL 64 B 483        +DUINKER,OLSSCN,STEFFEN,HEINTZE+(DESY+HEID)
BARTEL 2  76 TBILISI CONF.N56   +DUINKER,OLSSON,HEINTZE,+       (DESY+HEID)
SNYDER    76 PRL 36 1415        +HOM,LEDERMAN,APPEL,KAPLAN+(COLU+FNAL+STON)
TANENBAU  76 PRL 36 402         TANENBAUM,ABRAMS,BOYARSKI,BULOS,+(SLAC+LBL)IG
WHITAKER  76 PRL 37 1596        +TANENBAUM,ABRAMS,ALAM,BOYARSKI,+(SLAC+LBL)

BIDDICK   77 PRL 38 1324        +BURNETT+     (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
BRAUNSCH  77 PL 67 B 249        BRAUNSCHWEIG,+    (AACH+DESY+HAMB+MPIM+TOKY)
BURMESTE  77 PL 66 B 395        BURMESTER,CRIEGEE,+    (DESY+HAMB+SIEG+WUPP)
FELDMAN   77 PL 33 C 285        +PERL                            (LBL+SLAC)
YAMADA    77 HAMB. CONF. P. 69  YAMADA                          (DESY+TOKY)

BARTEL    78 PL 79 B 492        DITTMANN,DUINKER,OLSSON,O+NEILL+(DESY+HEID)
TANENBAU  78 PR D 17 1731       TANENBAUM,ALAM,BOYARSKI,+        (SLAC+LBL)

BARATE    79  PREP. DPHPE 79-17+BAREYRE,BONAMI,+      (SACL+LOIC+SHMP+IND)
BRANDEL1  79 ZPHY C 1 233       BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TCKY)
BRANDEL2  79 NP B 160 426       BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
PARTRID1  79  SLAC-PUB 2386     PARTRIDGE,PECK,+  (CIT+HARV+PRIN+SLAC+STAN)
PARTRID2  79  SLAC-PUB 2425     PARTRIDGE,PECK,+  (CIT+HARV+PRIN+SLAC+STAN)

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ψ(3770)

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   53  PSI(3770,JPG=1- ) I=
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                   53  PSI(3770) MASS (MEV)

M          3772.0      6.0            RAPIDIS    77 SMAG  O E+E-               12/77
M          3770.       6.0            BACINO     78 SPEC  O E+E- (DELCO)        4/78*
M          3764.0      5.0            ABRAMS     79 SMAG    E+ E-              12/79*
M          . . . . . . . . .
M    AVG   3768.1      3.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    STUDENT3768.1     3.6      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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                   53  PSI(3770)-PSI(3685) MASS DIFFERENCE (MEV)
DM           88.0      3.0            RAPIDIS    77 SMAG    E+E-               12/77
DM           80.0      2.0            ABRAMS     79 SMAG    E+ E-              12/79*
DM         . . . . . . . . .
DM   AVG     82.5      3.7      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
DM   STUDENT 82.2      2.2      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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                   53  PSI(3770) WIDTH (MEV)

W            28.0      5.0            RAPIDIS    77 SMAG  O E+E-               12/77
W            24.0      5.0            BACINO     78 SPEC  O E+E- (DELCC)        4/78*
W            24.0      5.0            ABRAMS     79 SMAG    E+ E-              12/79*
W          . . . . . . . . .
W    AVG     25.3      2.9      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W    STUDENT 25.3      3.1      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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                   53  PSI(3770) PARTIAL WIDTHS (KEV)

W1      PSI(3770) INTO E+E-
W1 R         0.37      0.09           RAPIDIS    77 SMAG  O E+E-               12/77
W1           0.18      0.06           BACINO     78 SPEC  O E+E- (DELCO)        4/78*
W1           0.276     0.050          ABRAMS     79 SMAG    E+ E-              12/79*
W1 R     SEE ALSO R2 BELOW
W1         . . . . . . . . .
W1   AVG     0.257     0.046    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
W1   STUDENT 0.259     0.042    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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Data Card Listings

Mesons

For notation, see key at front of Listings. $\psi(3770)$, $\psi(4030)$, $\psi(4160)$, $\psi(4415)$, $\Upsilon(9460)$

53 PSI(3770) PARTIAL DECAY MODES

		DECAY MASSES
P1	PSI(3770) INTO E+ E-	.5+ .5
P2	PSI(3770) INTO D DBAR	1868+1868

53 PSI(3770) BRANCHING RATIOS

R1 PSI(3770) INTO (D DBAR)/TOTAL (P2)
R1 DOMINANT PERUZZI 77 SMAG E+E-,D DBAR 12/77

R2 PSI(3770) INTO (E+ E-)/TOTAL (UNITS 10**-5) (P1)
R2 1.3 0.2 RAPIDIS 77 SMAG 0 E+E- 12/77

REFERENCES FOR PSI(3770)

PERUZZI 77 PRL 39 1301 +PICCOLO,FELDMAN,PERL,+(SLAC,LBL,NWES+HAWA)
RAPIDIS 77 PRL 39 526 +GOBBI,LUKE,PERL,+(STAN+SLAC+LBL+NWES+HAWA)
BACINO 78 PRL 40 671 +BAUMGARTEN,BIRKWOOD,+ (SLAC+STAN+UCLA+UCI)
ABRAMS 79 SLAC-PUB 2411 ALAM,BLOCKER,BOYARSKI,+ (SLAC+LBL)

$\psi(4030)$

72 PSI(4030,JPG=1-) I=

SEEN CLEARLY SEPARATED FROM THE PSI(4160)
BY DASP AND CONFIRMED WITH LESS STATISTICS BY PLUTO
SEEN ALSO BY MARK I, DELCO AND THE CRYSTAL BALL
(KIRKBY 79).

72 PSI(4030) MASS (MEV)

M 4028.0 2.5 GOLDHABER 77 SMAG E+E- 12/77
M 4040.0 10.0 BRANDELIK 78 DASP E+E- 4/78*
M . . . .
M AVG 4028.7 2.8 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
M STUDENT4028.6 2.7 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

72 PSI(4030) WIDTH (MEV)

W 52.0 10.0 BRANDELIK 78 DASP E+E- 4/78*

72 PSI(4030) PARTIAL DECAY MODES

		DECAY MASSES
P1	PSI(4030) INTO D DBAR	1868+1868
P2	PSI(4030) INTO D* DBAR AND D*BAR D	2006+1863
P3	PSI(4030) INTO D* D*BAR	2006+2006
P4	PSI(4030) INTO J/PSI(3100) HADRONS	
P5	PSI(4030) INTO E+ E-	.5+ .5
P6	PSI(4030) INTO MU+ MU-	105+ 105

72 PSI(4030) PARTIAL WIDTHS (KEV)

W1 0.75 0.15 BRANDELIK 78 DASP E+ E- 12/78*

72 PSI(4030) BRANCHING RATIOS

R1 PSI(4030) INTO (D DBAR)/(D* DBAR+D*BAR D) (P1)/(P2)
R1 0.05 0.03 GOLDHABER 77 SMAG 0 E+ E- 12/77

R2 PSI(4030) INTO J/PSI(3100) HADRONS (P4)
R2 LOOKED FOR BURMESTER 77 PLUT E+E- 4/77

R3 PSI(4030) INTO (D* D*BAR)/(D* DBAR+D*BAR D) (P3)/(P2)
R3 32.0 12.0 GOLDHABER 77 SMAG 0 E+ E- 12/77

R4 PSI(4030) INTO (E+ E-)/TOTAL (UNITS 10**-5) (P5)
R4 (1.0) APPROX. FELDMAN 77 SMAG E+ E- 12/77

REFERENCES FOR PSI(4030)

AUGUSTIN 75 PRL 34 764 +BOYARSKI,ABRAMS,BRIGGS+ (SLAC+LBL)
BACCI 75 PL 58B 481 +BIDOLI,PENSO,STELLA,+ (ROMA+FRAS)
BOYARSKI 75 PRL 34 762 +BREIDENBACH,ABRAMS,BRIGGS,+ (SLAC+LBL)
ESPOSITO 75 PL 58B 478 +FELICETTI,PERUZZI,+ (FRAS+NAPL+PADO+RCMA)

PERUZZI 76 PRL 37 569 +PICCOLO,FELDMAN,NGUYEN,WISS,+ (SLAC+LBL)

BURMESTE 77 PL 66 B 395 +CRIEGEE,DEHNE+ (DESY+HAMB+SIEG+WUPP)
GOLDHABE 77 PL 69 B 503 GOLDHABER,WISS,ABRAMS,ALAM,LUTH,+(LBL+SLAC)
FELDMAN 77 PL 33 C 285 +PERL (LBL+SLAC)
LUTH 77 PL 70 B 120 +PIERRE,ABRAMS,ALAM,BOYARSKI,+ (LBL+SLAC)

BRANDELI 78 PL 76 B 361 BRANDELIK,CORDS+ (AACH+DESY+HAMB+MPIM+TOKY)
ALSO 79 ZPHY C 1 233 BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
KIRKBY 79 BATAVIA CONF. J. KIRKBY RAPPORTEUR (SLAC)

$\psi(4160)$

25 PSI(4160,JPG=1-) I=

SEEN CLEARLY SEPARATED FROM THE PSI(4030)
BY DASP AND CONFIRMED WITH LESS STATISTICS BY PLUTO .
MARK I,DELCO AND THE CRYSTAL BALL SEE A PROMINENT
SHOULDER BUT NO SEPARATION (KIRKBY 79)

25 PSI(4160) MASS (MEV)

M 4159.0 20.0 BRANDELIK 78 DASP E+E- 4/78*

25 PSI(4160) WIDTH (MEV)

W 78.0 20.0 BRANDELIK 78 DASP E+E- 4/78*

25 PSI(4160) PARTIAL DECAY MODES

		DECAY MASSES
P1	PSI(4160) INTO E+ E-	.5+ .5

25 PSI(4160) PARTIAL WIDTHS (KEV)

W1 PSI(4160) INTO E+ E- 12/78*

W1 0.77 0.23 BRANDELIK 78 DASP E+ E- 12/78*

REFERENCES FOR PSI(4160)

BURMESTE 77 PL 66 B 395 +CRIEGEE,DEHNE+ (DESY+HAMB+SIEG+WUPP)
BRANDELI 78 PL 76 B 361 BRANDELIK,CORDS+ (AACH+DESY+HAMB+MPIM+TOKY)
KIRKBY 79 BATAVIA CONF. J. KIRKBY RAPPORTEUR (SLAC)

$\psi(4415)$

73 PSI(4415,JPG=1-) I=

73 PSI(4415) MASS (MEV)

M 4414. 7. SIEGRIST 76 SMAG E+E- 2/76
M (4400.) APPROX. KNIES 77 PLUT 0 E+E-,MU+ MU- 12/77
M 4417.0 10.0 BRANDELIK 78 DASP E+E- 4/78*
M . . . .
M AVG 4415.0 5.7 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M STUDENT4415.0 6.2 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

73 PSI(4415) WIDTH (MEV)

W 33. 10. SIEGRIST 76 SMAG E+E- 2/76
W 66.0 15.0 BRANDELIK 78 DASP E+E- 4/78*
W . . . .
W AVG 43.2 15.2 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
W STUDENT 42.4 10.4 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

73 PSI(4415) PARTIAL DECAY MODES

		DECAY MASSES
P1	PSI(4415) INTO E+ E-	.5+ .5

73 PSI(4415) PARTIAL WIDTHS (KEV)

W1 0.49 0.13 BRANDELIK 78 DASP E+ E- 12/78*

73 PSI(4415) BRANCHING RATIOS

R1 PSI(4415) INTO (E+ E-)/TOTAL (UNITS 10**-5)
R1 1.3 .3 SIEGRIST 76 SMAG E+E- 2/76

R2 PSI(4415) INTO HADRONS/TOTAL
R2 DOMINANT SIEGRIST 76 SMAG E+E- 1/77

REFERENCES FOR PSI(4415)

SIEGRIST 76 PRL 36 700 +ABRAMS,BOYARSKI,BREIDENBACH,+ (LBL+SLAC)

BURMESTE 77 PL 66 B 395 +CRIEGEE,DEHNE+ (DESY+HAMB+SIEG+WUPP)
KNIES 77 DESY 77/74 G.KNIES HAMBURG TALK ON PLUTO COLLAB.(DESY)
LUTH 77 PL 70 B 120 +PIERRE,ABRAMS,ALAM,BOYARSKI,+ (LBL+SLAC)

BRANDELI 78 PL 76 B 361 BRANDELIK,CORDS+ (AACH+DESY+HAMB+MPIM+TCKY)

$\Upsilon(9460)$

49 UPSILON (9460,JPG=1-) I=

49 UPSILON(9460) MASS (MEV)

M I (9410.) (13.) INNES 77 SPEC 0 400 P+A,MU+MU- 12/77
M CB (9460.0) (10.0) BERGER 78 PLUT E+E- 4/78*
M C 9460.0 10.0 BIENLEIN 78 CNTR E+E- 4/78*
M D 9456.3 11.0 BERGER 79 PLUT E+E- 12/79*
M C 9457.0 10.0 DARDEN 79 DASP E+E- 12/79*
M . . . .
M AVG 9457.9 5.9 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M STUDENT9457.9 6.4 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M B DATA INCLUDED IN BERGER 79
M C ERRORS COMPLETELY CORRELATED
M D 10 MEV SYSTEMATIC ERROR ADDED LINEARLY BY US.
M I FROM 2-PEAK FIT

49 UPSILON(9460) WIDTH (MEV)

W AB (18.0) OR LESS BERGER 78 PLUT E+E- 4/78*
W A (8.0) OR LESS BIENLEIN 78 CNTR E+E- 4/78*
W E (0.023)OR MORE CL=0.95 BERGER 79 PLUT E+E- 12/79*
W (0.060) DARDEN 79 DASP E+E- 12/79*

W A FROM QUOTED RESOLUTION
W B DATA INCLUDED IN BERGER 79
W E FROM R1 AND ASSUMING E-MU UNIVERSALITY

Mesons

Υ(9460), Υ(10020), Υ(10400), $K^{\pm}$, K^0, $K^*(892)$

Data Card Listings

For notation, see key at front of Listings.

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                 49  UPSILON(9460) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      UPSILCN(9460)  INTO MU+ MU-                      105+ 105
P2      UPSILCN(9460)  INTO  E+  E-                       .5+  .5

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                 49  UPSILON(9460) PARTIAL WIDTHS (KEV)

W1      UPSILCN(9460)  INTO  E+  E-                  (G2)
W1 CBD      (1.3)     (0.4)        BERGER     78 PLUT    E+E-          4/78*
W1 C         1.04      0.28        BIENLEIN   78 CNTR    E+E-          4/78*
W1           1.33      0.14        BERGER     79 PLUT    E+E-         12/79*
W1 C         1.5       0.4         DARDEN     79 DASP    E+E-         12/79*
W1          . . . . . . . . .
W1  AVG      1.29      0.12    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W1  STUDENT  1.29      0.13    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W1  B    DATA INCLUDED IN BERGER 79
W1  C    ERRORS CORRELATED
W1   D   WITH RADIATIVE CORRECTIONS IN

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                 49  UPSILON(9460) BRANCHING RATIOS

R1      UPSILCN(9460)  INTO(MU+ MU-)/TOTAL            (P1)
R1           0.022     0.020       BERGER     79 PLUT    E+E-         12/79*

R2      UPSILON(9460)  INTO (E+  E-)/TOTAL            (P2)
R2           SEEN                  COBB       77 SPEC    P P,E+ E- X  12/78*
R2           0.025     0.021       DARDEN     79 DASP    E+E-         12/79*

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                              REFERENCES FOR UPSILON (9460)

COBB      77 PL 72 B 273      +IWATA,FABJAN,GOLDBERG+(BNL+CERN+SYRA+YALE)
HERB      77 PRL 39 252       +HOM,LEDERMAN,APPEL,ITO,+   (COLU+FNAL+STON)
INNES     77 PRL 39 1240      +APPEL,BROWN,HERB,HOM,FISK+(COLU+FNAL+STON)

BERGER    78 PL 76 B 243      +ALEXANDER,DAUM,+(AACH+DESY+HAMB+SIEG+WUPG)
BIENLEIN  78 PL 78 B 360      +GLAWE,BOCK,BLANAR,+   (DESY+HAMB+HEID+MPIM)
DARDEN    78 PL 76 B 246      +HOFMANN,ALBRECHT,+     (DESY+DORT+HEID+LUND)
GARELICK  78 PR D 18 945      +GAUTHIER,HICKS,OLIVER,+    (NEAS+WASH+TUFT)
KAPLAN    78 PRL 40 435       +APPEL,HERB,HOM,LEDERMAN,+ (STON+FNAL+CCLU)
YOH       78 PRL 41 684       +HERB,HOM,LEDERMAN,UENO,+   (COLU+FNAL+STON)

ANGELIS   79 PC 87 B 398      +BESCH,BLUMENFELD,+      (CERN+CCLU+OXF+ROCK)
BADIER    79 PL 86 B 98       +BOUCROT,BURGUN+ (SACL+CERN+CDEF+EPOL+LALO)
BERGER    79 ZPHY C 1 343     +ALEXANDER+          (AACH+DESY+HAMB+SIEG+WUPG)
DARDEN    79 PL 80 B 419      +HOFMANN,ALBRECHT,+     (DESY+DORT+HEID+LUND)
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Υ(10020)

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52  UPSILON(10020,JPG=1- ) I=
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                 52  UPSILON(10020) MASS  (GEV)

M  I         10.060    (0.030)       INNES      77 SPEC    400 P+A,MU+MU-    12/77
M  C         10.020     0.020        BIENLEIN   78 CNTR    E+E-               4/78*
M  C         10.012     0.020        DARDEN     78 DASP    E+E-               4/78*
M           . . . . . . . . .
M   AVG      10.016     0.014    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT  10.016     0.015    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M  C    ERRORS COMPLETELY CORRELATED
M  I    FROM 2-PEAK FIT

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                 52  UPSILON(10020) WIDTH (MEV)

W  A         (12.0)  OR LESS          BIENLEIN   78 CNTR    E+E-           4/78*
W  A         (18.0)  OR LESS          DARDEN     78 DASP    E+E-           4/78*
W  A    FROM QUOTED RESOLUTION

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                 52  UPSILON(10020)-UPSILON(9460) MASS DIFFERENCE (MEV)

DM C        560.0      10.0           BIENLEIN   78 CNTR    E+E-                4/78*
DM C        555.0      11.0           DARDEN     78 DASP    E+E-                4/78*
DM A        574.0      27.0           UENO       79 SPEC    400 P PT,MU+MU-    12/79*
DM          . . . . . . . . .
DM  AVG     558.9       7.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
DM  STUDENT 558.9       7.7      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

DM A    FIXING THE UPSILON(9460) MASS AT 9460 MEV
DM C    ERRORS COMPLETELY CORRELATED

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                 52  UPSILON(10020) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      UPSILON(10020) INTO MU+ MU-                      105+ 105
P2      UPSILCN(10020) INTO  E+  E-                       .5+  .5

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                 52  UPSILON(10020) PARTIAL WIDTHS (KEV)

W1      UPSILCN(10020) INTO  E+  E-                  (G2)
W1 C         0.32      0.13        BIENLEIN   78 CNTR    E+E-          4/78*
W1 C         0.35      0.14        DARDEN     78 DASP    E+E-          4/78*
W1          . . . . . . . . .
W1  AVG      0.334     0.095   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W1  STUDENT  0.33      0.10    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W1 C    ERRORS COMPLETELY CORRELATED

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                 52  UPSILON(10020) BRANCHING RATIOS

R1      UPSILON(10020) INTO(MU+ MU-)/TOTAL            (P1)
R1           SEEN                  HERB       77 SPEC    400 P A,MU+ MU- 12/78*
R2      UPSILON(10020) INTO (E+  E-)/TOTAL            (P2)
R2           SEEN                  COBB       77 SPEC    P P,E+ E- X     12/78*

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                              REFERENCES FOR UPSILON(10020)

COBB      77 PL 72 B 273      +IWATA,FABJAN,GOLDBERG+(BNL+CERN+SYRA+YALE)
HERB      77 PRL 39 252       +HOM,LEDERMAN,APPEL,ITO,+   (COLU+FNAL+STON)
INNES     77 PRL 39 1240      +APPEL,BROWN,HERB,HOM,FISK+(COLU+FNAL+STON)

BIENLEIN  78 PL 78 B 360      +GLAWE,BOCK,BLANAR,+   (DESY+HAMB+HEID+MPIM)
DARDEN    78 PL 78 B 364      +HOFMANN,ALBRECHT,+     (DESY+DORT+HEID+LUND)
KAPLAN    78 PRL 40 435       +APPEL,HERB,HOM,LEDERMAN,+ (STON+FNAL+CCLU)
YOH       78 PRL 41 684       +HERB,HOM,LEDERMAN,UENO,+   (COLU+FNAL+STON)

UENO      79 PRL 42 486       +BROWN,HERB,HOM,FISK,ITC,+ (FNAL+COLU+STON)
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Υ(10400)

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48  UPSILON (10400,JPG=1- ) I=
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                 48  UPSILON(10400)-UPSILON(9460) MASS DIFFERENCE (MEV)

DM A        950.0      30.0           UENO       79 SPEC    400 P PT,MU+MU-  12/79*

DM A    FIXING THE UPSILON(9460) MASS AT 9460 MEV AND THE
DM A    UPSILON(10020)-UPSILON(9460) MASS DIFFERENCE AT 558 MEV.

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                              REFERENCES FOR UPSILON(10400)

COBB      77 PL 72 B 273      +IWATA,FABJAN,GOLDBERG+(BNL+CERN+SYRA+YALE)
HERB      77 PRL 39 252       +HOM,LEDERMAN,APPEL,ITO,+   (COLU+FNAL+STON)
INNES     77 PRL 39 1240      +APPEL,BROWN,HERB,HOM,FISK+(COLU+FNAL+STON)

KAPLAN    78 PRL 40 435       +APPEL,HERB,HOM,LEDERMAN,+ (STON+FNAL+COLU)
YOH       78 PRL 41 684       +HERB,HOM,LEDERMAN,UENO,+   (COLU+FNAL+STON)

UENO      79 PRL 42 486       +BROWN,HERB,HOM,FISK,ITO,+ (FNAL+COLU+STON)
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S=±1, C=0 MESON STATES

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$K^{\pm}$

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10  CHARGED K(494,JP=0-) I=1/2
    SEE STABLE PARTICLE DATA CARD LISTINGS

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K^0

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11  NEUTRAL K(498,JP=0-) I=1/2
    SEE STABLE PARTICLE DATA CARD LISTINGS

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$K^*(892)$

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18  K*(892,JP=1-) I=1/2
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                 18  K*(892) MASS (MEV)

M  CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE
M   S  100 (898.0)    (5.0)          CHADWICK  63 HBC  +   1.5 K+P(K PI)    12/75
M  W  1700  891.0      1.2           WOJCICKI  64 HBC  -   1.7 K-P(KO PI-)  12/75
M   SD 200 (889.5)    (3.6)          ADELMAN   65 HBC  -   1.5 K-P          12/75
M   S  300 (891.0)    (3.0)          FERRO-LUZ 65 HBC  +     K+P            12/75
M   S  300 (895.0)    (3.0)          GELSEMA   65 HBC  -   1.5 K-P(KO PI-)  12/75
M   SD 190 (895.)     (3.6)          BOMSE     67 HBC  +  2.3 K+P (KO PI+)  12/75
M    D 620  891.       2.3           DE BAERE  67 HBC  +  3.5 K+P (KO PI+)  12/75
M   SD 260 (892.5)    (3.3)          DE BAERE  67 HBC  +  3.5 K+P (K+ PIO)  12/75
M   SD  70 (898.)     (9.0)          SALLSTROM 67 HBC  +  3. K+ P (KO PI+)  12/75
M   SD  50 (883.)     (7.0)          SALLSTROM 67 HBC  +  3. K+ P (K+ PIO)  12/75
M      720  890.       3.0           BARLOW    67 HBC  +- 1.2 PBARP(KO PI)  12/75
M      600  889.       3.0           BARLOW    67 HBC  +- 1.2 PBARP(K PI)   12/75
M   S  300 (856.0)    (5.0)          CONFCRTO  67 HBC  +- 0. PBARP(KO PI)   12/75
M   S  430 (893.)     (3.0)          DE WIT    68 DBC   - 3.0 K-P(KOPI-)    12/75
M    D 540  888.       2.5           DE WIT    68 HBC   - 3.0 K-P           12/75
M   S      (891.)     (4.0)          FICENEC1  68 HBC  -   1.3 K-P (K-PIO)  12/75
M   S      (887.)     (3.0)          FICENEC1  68 HBC  -   1.3 K-P (KOPI-)  12/75
M   S      (890.0)    (5.0)          FICENEC2  68 HBC  -   2.7 K- P(K-PIO)  12/75
M   S      (892.0)    (3.0)          FICENEC2  68 HBC  -   2.7 K- P(KOPI-)  12/75
M   S  115 (896.0)    (4.0)          SCHWEINGR 68 HBC  -   4.1 K-P(KO PI-)  12/75
M    D 341  892.0      2.6           SCHWEINGR 68 HBC  -   5.5 K-P(KO PI-)  12/75
M   S  175 (884.0)    (5.0)          KANG      68 HBC  -   4.6 K-P(K PI)    12/75
M     1000  891.0      2.0           CRENNELL  69 DBC  -   3.9 K-N (KOPI-)  12/75
M     2886  894.       1.0           FRIEDMAN  69 HBC  -   2.1 K-P(KO PI-)  12/75
M      728  892.       2.            FRIEDMAN  69 HBC  - 2.45 K-P(KO PI-)   12/75
M     3229  892.       1.0           FRIEDMAN  69 HBC  - 2.6  K-P(KO PI-)   12/75
M    D1027  892.       1.6           FRIEDMAN  69 HBC  - 2.7  K-P(KO PI-)   12/75
M   SD 127 (895.)     (4.5)          LIND      69 HBC  +   9. K+ P          12/75
M     4404  892.2      1.5           AGUILAR1  71 HBC  -   3.9,4.6 K- P     11/71
M    D 765  894.2      2.0           CLARK     73 HBC  - 3.13 K-P(KO PI-)   12/75
M  W D1150  894.3      1.5           CLARK     73 HBC  -  3.3 K-P,P PI- KO  12/75
M   I 9000 (891.9)    (0.7)          PALER     75 HBC  - 14.3 K-P,K*- X+    12/75
M     1800  890.7      0.9           AGUILAR   78 HBC  +- .76 PB P,K KS PI  12/78*
M     1225  886.6      2.4           BALAND    78 HBC  +- 12 PB P,INCLUSIV   4/78*
M     6706  891.7      0.6           COOPER    78 HBC  +- .76 PB P,INCLUSV   4/78*
M  XS      (892.4)    (5.0)          MARTIN    78 SPEC +- 10 K+-P,KS PI P   12/78*
M          . . . . . . . . .
M   AVG     891.79     0.36    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
M   STUDENT 891.74     0.38    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M  NEUTRAL ONLY.
M   S   70 (897.0)   (10.0)          COLLEY    62 HBC    0 2.0 PI-P         12/75
M   S  120 (899.)     (4.0)          BARLOW    67 HBC    0 1.2 PBAR P       12/75
M   S  310 (897.)     (4.0)          BARLOW    67 HBC    0 1.2 PBAR P       12/75
M   S      (889.0)    (5.0)          CONFORTO  67 HBC    0 0. PBAR P        12/75
M    D1040  894.7      1.4           DAUBER    67 HBC    02.0 K-P(K-PI+)    12/75
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Data Card Listings

For notation, see key at front of Listings.

Mesons

K*(892)

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M  AS  490 (892.0)     (4.0)              GEORGE     67 HBC    0 5.0 K+ P          12/75
M   SD     (895.)      (4.0)              FICENEC1   68 HBC    0 1.3 K-P (K-PI+)   12/75
M   SD     (901.)      (4.0)              FICENEC2   68 HBC    0 2.7 K-P (K-PI+)   12/75
M   SD 150 (896.0)     (4.5)              SCHWEINGR  68 HBC    0 4.1 K-P(K-PI+)    12/75
M   SD120  (903.0)     (5.0)              SCHWEINGR  68 HBC    0 5.5 K-P(K-PI+)    12/75
M   S  200 (899.0)     (5.0)              KANG       68 HBC    0 4.6 K-P(K-PI+)    12/75
M       10K 893.7       2.0               DAVIS      69 HBC    0 12. K+P(K+PI-)    12/75
M  WAD2200 (890.0)     (1.3)              DE BAERE   69 HBC    0 5.0 K+P(K+PI-)    12/75
M  W  4300  895.0       1.0               HABER      70 DBC    0 3. K-N (K-PI+)    12/75
M    D2934  897.9       1.1               AGUILAR1   71 HBC    0 3.9,4.6 K- P      12/75
M    D5362  898.0       0.7               AGUILAR1   71 HBC    0 3.9,4.6 K- P      12/75
M    D1700  898.4       1.3               BUCHNER    72 DBC    04.6 K+ N,K+ PI-    12/72
M     3186  896.0       1.0               LEWIS      73 HBC    02.1-2.7 K+P         2/74
M    C      894.0       1.3               LINGLIN    73 HBC    02-13 K+P,K+PI-     12/75
M       10K 896.0       0.6               FOX        74 RVUE   0 2 K-P,K-PI+N      12/75
M           896.0       0.6               FOX        74 RVUE   0 2 K+N,K+PI-P      12/75
M    C      896.        2.                MATISON    74 HBC    012 K+P,K+PI-       12/75
M     3600  895.5       1.0               MCCUBBIN   75 HBC    0 3.6 K-P,K-PI+N    12/75
M   I  22K (897.1)     (0.7)              PALER      75 HBC    014.3 K-P,K*0 X0    12/75
M           897.6       0.9               BOWLER     77 DBC    05.4 K+D,K+PI-P P   12/77
M     1180  898.4       1.4               AGUILAR    78 HBC   0 .76 PB P,K KS PI   12/78*
M  P        895.7       0.3               ESTABROOK  78 ASPK   013 K+-P,K+-PI+-    12/77
M           894.9       1.6               WICKLUND   78 ASPK  0 3,4,6 PI+-PN        4/78*
M          . . . . . . . . .
M   AVG     896.10      0.26    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
M   STUDENT 896.02      0.24    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )
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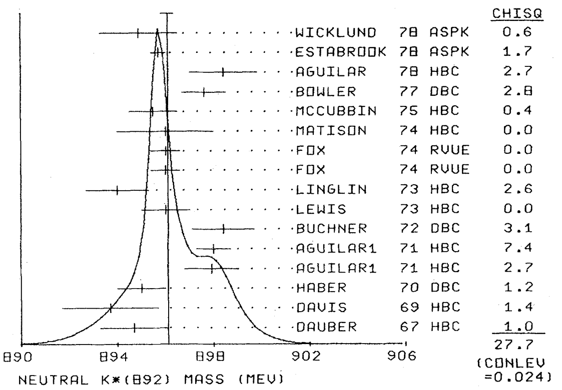
WEIGHTED AVERAGE = 896.10 ± 0.26
ERROR SCALED BY 1.4

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M   A   INCLUDED IN LINGLIN 73 WORLD K+P DST
M    C  FROM POLE EXTRAPOLATION.
M    D  MASS ERRORS ENLARGED BY US TO   GAMMA/SQRT(N). SEE TYPED NOTE.
M   I   INCLUSIVE REACTION. COMPLICATED BACKGROUND AND PHASE-SPACE EFFECTS
M  P    FROM PHASE SHIFT ANALYSIS OF 155000 EVENTS.
M   S   DATA WITH MASS ERROR OF 3 MEV OR MORE NOT AVERAGED
M  W    NUMBER OF EVENTS IN PEAK REEVALUATED BY US
M  X    SYSTEMATIC ERROR ADDED
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Note on K*(892) Masses and Mass Differences

Unrealistically small errors are reported by some experiments. We use simple "realistic" tests for the minimum errors on the determination of mass and width from a sample of N events:

$$\delta_{min}(m) = \frac{\Gamma}{\sqrt{N}} , \qquad \delta_{min}(\Gamma) = 4\frac{\Gamma}{\sqrt{N}} .$$

(For detailed discussion see the April 1971 edition of this note.) We consistently increase unrealistic errors before averaging.

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                        18  K*(0) - K*(+-) MASS DIFF. (MEV)

D  W   283    6.3      4.1               BARASH    67 HBC      0 PBAR P          12/75
D   SD1400   (6.5)    (5.0)              FICENEC1  68 HBC        1.3 K- P        12/75
D   SD1600   (9.5)    (5.0)              FICENEC2  68 HBC        2.7 K- P        12/75
D     7338    5.7      1.7               AGUILAR1  71 HBC    -0 3.9,4.6 K- P     11/71
D     2980    7.7      1.7               AGUILAR   78 HBC   +- .76 PB P,K KS PI  12/78*
D          . . . . . . . . .
D   AVG       6.7      1.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D   STUDENT   6.7      1.3     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

D    D  MASS ERRORS ENLARGED BY US TO   GAMMA/SQRT(N). SEE TYPED NOTE.
D   S   DATA WITH MASS ERROR OF 3 MEV OR MORE NOT AVERAGED
D  W    NUMBER OF EVENTS IN PEAK REEVALUATED BY US
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                  18  K*(892) WIDTH (MEV)

W  CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE
W   S  100  (46.0)    (8.0)            CHADWICK  63 HBC  +   1.5 K+P(K PI )   12/75
W  W D1700   46.0      5.0             WOJCICKI  64 HBC  -   1.7 K-P(K0 PI-)  12/75
W   SD 200  (51.0)    (15.0)           ADELMAN   65 HBC  -   1.5 K-P          12/75
W   SD 300  (47.0)    (11.0)           FERRO-LUZ 65 HBC  +   3.0 K+P          12/75
W   SD 300  (50.0)    (12.0)           GELSEMA   65 HBC  -   1.5 K-P(K0 PI-)  12/75
W   SD 190  (50.)     (15.0)           BOMSE     67 HBC  +   2.3 K+P(K0 PI+)  12/75
W    D 620   56.0      9.0             DE BAERE  67 HBC  +   3.5 K+P(K0 PI+)  12/75
W   SD 260  (53.)     (13.0)           DE BAERE  67 HBC  +  3.5 K+P (K+ PI0)  12/75
W   SD  70  (68.)     (33.0)           SALLSTROM 67 HBC  +  3. K+ P (K0 PI+)  12/75
W   SD  50  (47.)     (27.0)           SALLSTROM 67 HBC  +  3. K+ P (K+ PI0)  12/75
W   SD 210  (44.)     (12.0)           BARLOW    67 HBC  +-  1.2 PBAR P       12/75
W       720  43.       9.0             BARLOW    67 HBC  +- 1.2 PBARP(K0 PI) 12/75
W    D 600   53.       9.0             BARLOW    67 HBC  +- 1.2 PBARP(K PI)  12/75
W   SD 430  (58.)     (12.0)           DE WIT    68 DBC  -   3. K- D          12/75
W    D 540   44.0      8.0             DE WIT    68 DBC  -   3. K- D          12/75
W   S       (58.)     (16.0)           FICENEC1  68 HBC  -   1.3 K-P (K-PI0)  12/75
W   S       (44.)     (13.0)           FICENEC1  68 HBC  -   1.3 K-P (K0PI-)  12/75
W   SD 115  (41.0)    (16.0)           SCHWEINGR 68 HBC  -   4.1 K-P(K0 PI-)  12/75
W   SD 341  (47.0)    (10.0)           SCHWEINGR 68 HBC  -   5.5 K-P(K0 PI-)  12/75
W   S       (57.0)    (13.0)           FICENEC2  68 HBC  -   2.7 K- P(K-PI0)  12/75
W   S       (48.0)    (9.0)            FICENEC2  68 HBC  -   2.7 K- P(K0PI-)  12/75
W   SD 175  (52.0)    (16.0)           KANG      68 HBC  -   4.6 K- P         12/75
W    D2886   53.       4.0             FRIEDMAN  69 HBC  -   2.1 K-P(K0 PI-)  12/75
W    D 728   49.       7.3             FRIEDMAN  69 HBC  -   2.45K-P(K0 PI-)  12/75
W    D3229   46.       3.2             FRIEDMAN  69 HBC  -   2.6 K-P(K0 PI-)  12/75
W    D1027   49.       6.1             FRIEDMAN  69 HBC  -   2.7 K-P(K0 PI-)  12/75
W   SD 127  (50.)     (18.0)           LIND      69 HBC  +   9. K+ P          12/75
W    D4404   54.3      3.3             AGUILAR1  71 HBC  -   3.9,4.6 K- P     12/75
W    D 765   46.3      6.7             CLARK     73 HBC  -  3.13K-P,P PI- K0 12/75
W  W D1150   48.2      5.7             CLARK     73 HBC  -  3.3 K-P,P PI- K0 12/75
W   I 9000  (52.1)    (2.2)            PALER     75 HBC  - 14.3 K-P,K*- X+   12/75
W     1800   45.8      3.6             AGUILAR   78 HBC  +- .76 PB P,K KS PI 12/78*
W     1225   43.0      8.4             BALAND    78 HBC  +- 12 PB P,INCLUSIV  4/78*
W    D6706   52.0      2.5             COOPER    78 HBC  +- .76 PB P,INCLUSV  4/78*
W            50.9      1.0             MARTIN    78 SPEC +- 10 K+-P,KS PI P  12/78*
W           . . . . . . . . .
W   AVG      50.34     0.77   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W   STUDENT  50.38     0.87   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W  NEUTRAL ONLY.
W   SD  70  (60.0)    (29.0)           COLLEY    62 HBC    0 2.0 PI-P         12/75
W   S  310  (53.)     (13.0)           BARLOW    67 HBC    0 1.2 PBAR P       12/75
W   SD 120  (34.)     (12.5)           BARLOW    67 HBC    0 1.2 PBAR P       12/75
W    D1040   44.       5.5             DAUBER    67 HBC    0  2.0 K- P        12/75
W   S       (52.)     (12.0)           FICENEC1  68 HBC    0 1.3 K-P (K-PI+)  12/75
W   S       (50.0)    (8.0)            FICENEC2  68 HBC    0 2.7 K- P(K-PI+)  12/75
W   SD 200  (48.0)    (16.0)           KANG      68 HBC    0 4.6 K-P(K-PI+)   12/75
W   SD 120  (51.0)    (19.0)           SCHWEINGR 68 HBC    0 5.5 K-P(K-PI+)   12/75
W   SD 150  (53.0)    (17.5)           SCHWEINGR 68 HBC    0 4.1 K-P(K-PI+)   12/75
W    D 10K   53.2      2.1             DAVIS     69 HBC    0 12. K+P(K+PI-)   12/75
W  WAD2200  (58.0)    (5.0)            DE BAERE  69 HBC    0 5.0 K+P(K+PI-)   12/75
W  W D4300   54.0      3.3             HABER     70 DBC    0 3. K-N (K-PI+)   12/75
W     2934   55.8      4.2       3.4   AGUILAR1  71 HBC    0 3.9,4.6 K- P     11/71
W    D5362   48.5      2.7             AGUILAR1  71 HBC    0 3.9,4.6 K- P     12/75
W    D1700   51.4      5.0             BUCHNER   72 DBC    04.6 K+ N,K+ PI-P  12/72
W    D3186   46.0      3.3             LEWIS     73 HBC    02.1-2.7 K+P       12/75
W   C       (46.5)    (1.5)            LINGLIN   73 HBC    02-13 K+P,K+PI-     1/74
W       10K  47.       2.              FOX       74 RVUE   0 2 K-P,K-PI+N     12/75
W            51.       2.              FOX       74 RVUE   0 2 K+N,K+PI-P     12/75
W   C       (47.)     (3.)             MATISON   74 HBC    012 K+P,K+PI-      12/75
W     3600   48.       3.        2.    MCCUBBIN  75 HBC    0 3.6 K-P,K-PI+N   12/75
W   I  22K  (50.6)    (2.5)            PALER     75 HBC    014.3 K-P,K*0 X0   12/75
W            48.9      2.5             BOWLER    77 DBC    05.4 K+D,K+PI-P P  12/77
W     1180   45.9      4.8             AGUILAR   78 HBC   0 .76 PB P,K KS PI  12/78*
W  P         52.9      0.4             ESTABROOK 78 ASPK   013 K+-P,K+-PI+-   12/77
W            51.2      1.7             WICKLUND  78 ASPK  0 3,4,6 PI+-PN       4/78*
W           . . . . . . . . .
W   AVG      52.23     0.52   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
W   STUDENT  52.26     0.50   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )
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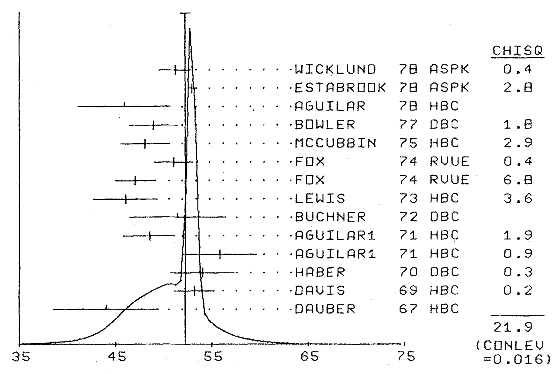
WEIGHTED AVERAGE = 52.23 ± 0.52
ERROR SCALED BY 1.5

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W   A   INCLUDED IN LINGLIN 73 WORLD K+P DST
W    C  FROM POLE EXTRAPOLATION.
W    D  WIDTH ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE.
W   I   INCLUSIVE REACTION. COMPLICATED BACKGROUND AND PHASE-SPACE EFFECTS
W  P    FROM PHASE SHIFT ANALYSIS OF 155000 EVENTS.
W   S   DATA WITH MASS ERROR OF 3 MEV OR MORE NOT AVERAGED
W  W    NUMBER OF EVENTS IN PEAK REEVALUATED BY US
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Mesons
$K^*(892)$, Q


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                 18  K*(892) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      K*(892) INTO K PI                               493+ 139
P2      K*(892) INTO K PI PI                            493+ 139+ 139
P3      K*(892) INTO K GAMMA                            493+   0

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                 18  K*(892) BRANCHING RATIOS

R1      K*(892) INTO (K PI PI)/(K PI)                 (P2)/(P1)
R1        0    (0.002)OR LESS         WOJCICKI2 64 HBC   -  1.7 K-P
R1        0    (0.0007)R LESS  CL=0.95  JONGEJANS 78 HBC    4 K-P,P K0 2PI    4/78*

R2      K*(892)  INTO (K  GAMMA)/TOTAL  (UNITS 10**-3)    (P3)
R2             (1.6)  OR LESS  CL=.95   BEMPORAD  72 CNTR +  10.-16. K+A,COUL  1/73
R2              1.5       0.7           CARITHERS 75 CNTR  0 8-16K0BAR A,COUL 12/75

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                             REFERENCES FOR K*(892)

ALSTON   61 PRL 6 300            ALSTON,ALVAREZ,EBERHARD,GOOD,GRAZIANO+(LRL)
ALEXANDE 62 PRL 8 447            ALEXANDER,KALBFLEISCH,MILLER,G SMITH  (LRL)
COLLEY   62 CERN CONF 315        D COLLEY,N GELFAND +     (COLUMBIA+RUTGERS)

CHADWICK 63 PL 6 309             CHADWICK,CRENNELL,DAVIES,BETTINI+(OXF+PADO)
GOLDHABE 63 ATHENS CONF 92       SULAMITH GOLDHABER                    (LRL)

WOJCICKI 64 PR 135 B 484         STANLEY G WOJCICKI                    (LRL)

ADELMAN  65 ATHENS 527           STUART LEE ADELMAN              (CAVENDISH)
FERRO-LU 65 NC 36 1101           FERRO-LUZZI,GEORGE,HENRI,JONGEJANS   (CERN)
FERRO-LU 65 NC 39 417            FERRO-LUZZI,GEORGE,GOLDSCHMIDT-CLER+ (CERN)
GELSEMA  65 THESIS               E.S.GELSEMA (SEE ALSO PL 10 341)(AMSTERDAM)
WANGLER  65 PR 137 B 414         WANGLER,ERWIN,WALKER            (WISCONSIN)

BARASH   67 PR  156  1399        BARASH,KIRSCH,MILLER,TAN         (COLUMBIA)
BARLOW   67 NC  50 A  701        +MONTANET,D-ANDLAU+   (CERN+CDEF+IRAD+LIVP)
BOMSE    67 PR 158 1298          +BORENSTEIN+COLE+GILLESPIE+  (JOHN HOPKINS)
CONFORTO 67 NP B3 469            +MARECHAL,MONTANET+CERN+CDEF+IPN+LIVERPOOL
DAUBER   67 PR 153 1403          +SCHLEIN,SLATER,TICHO                (UCLA)
DE BAERE 67 NC 51 A 401          +GOLDSCHMIDT-CLERMONT,HENRI+    (BRUX+CERN)
FRENCH   67 NC 42A 442           +KINSON+MCDONALD+RIDDIFORD+     (CERN+BIRM)
GEORGE   67 NC 49A 9             +GOLDSCHMIDT-CLERMONT+HENRI+    (CERN+BRUX)
SALLSTRO 67 NC 49A 348           SALLSTROM+OTTER+EKSPONG         (STOCKHOLM)

DE WIT   68  THESIS              S. DE WIT                       (AMSTERDAM)
FICENEC1 68 PR 169 1034          +HULSIZER+SWANSON+TROWER              (ILL)
FICENEC2 68 PR 175 1725          FICENEC, GORDON, TROWER          (ILLINOIS)
KANG     68 PR 176 1587          Y.W.KANG                             (IOWA)
SCHWEING 68 PR 166 1317          SCHWEINGRUBER,DERRICK,FIELDS+    (ANL+NWES)

CRENNELL 69 PRL 22  487          +KARSHON,LAI,ONEALL,SCARR             (BNL)
DAVIS    69 PRL 23 1071          +DERENZO,FLATTE,ALSTON,LYNCH,SOLMITZ  (LRL)
DE BAERE 69 NC 61 A 397          +GOLDSCHMIDT-CLERMONT,HENRI,+   (BELG+CERN)
FRIEDMAN 69  UCRL-18860          J.FRIEDMAN,PH.D. THESIS               (LRL)
JUHALA   69 PR 184  1461         +LEACOCK,RHODE,KOPELMAN,LIBBY,+  (ISU+COLO)
LIND     69 NP B 14 1            +ALEXANDER,FIRESTONE,FU,GOLDHABER     (LRL) JP

ATHERTON 70 NP B 16 416          +FRANEK,FRENCH,FRISK,BEDNAR+    (CERN+PRAG)
HABER    70 NP B 17 289          +SHAPIRA,ALEXANDER+   (REHO+SACL+BGNA+EPOL)

AGUILAR  71 PRL 26 466           +BARNES,BASSANO,EISNER,KINSON,SAMIOS  (BNL)
AGUILAR1 71 PR D 4 2583          +EISNER,KINSON                        (BNL)
BARNHAM  71 NP B 28 171          +COLLEY,JOBES,GRIFFITHS,HUGHES,+(BIRM+GLAS)
BUCHNER  71 NP B 29 381          +DEHM,GOEBEL,GOLDSCHMIDT,+ (MPIM+CERN+BELG)
CORDS    71 PR D 4 1974          +CARMONY,ERWIN,MEIERE,+    (PURD+UCD+IUPU)
MERCER   71 NP B32 381           +ANTICH,CALLAHAN,CHIEN,COX,+ (JOHN HOPKINS)
YUTA     71 PRL 26 1502          +DERRICK,ENGELMANN,MUSGRAVE       (ANL+EFI)

ABRAMOVI 72 NP B 39 189          ABRAMOVICH,CHALOUPKA,CHUNG,HILPERT,+ (CERN)
BINGHAM  72 NP B 41 1            +            (INTERNATIONAL K+ COLLABORATION)
BEMPORAD 72 NP B 51 1            +BEUSCH,FREUDENREICH,+       (CERN+ETH+LOIC)
BRUNET   72 NP B 37 114          +DANYSZ,GOLDSACK,+    (CDEF+SACL+LOIC+LOWC)
BUCHNER  72 NP B 45 333          +DEHM,CHARRIERE,CORNET,+   (MPIM+CERN+BRUX)
CRENNELL 72 PR D 6 1220          +GORDON,KWAN-WU LAI, SCARR            (BNL)
DEUTSCHM 72 NP B 36 373          DEUTSCHMANN,+            (ABCLV COLLABORATION)
ENGELMAN 72 PR D 5 2162          ENGELMANN,MUSGRAVE,FORMAN,+       (ANL+EFI)
ROUGE    72 NP B 46 29           +VIDEAU,VOLTE,DE BRION,+        (EPOL+SACL)
TIECKE   72 NP B 39 596          +GRIJNS,HEINEN,DE GROOT,+       (NIJM+AMST)

BERTHON  73 NP B 63 54           +MONTANET,PAUL,BERTRANET,+      (CERN+SACL)
CHARRIER 73 NP B 51 317          CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)
CLARK    73 NP B 54 432          +LYONS,RADOJICIC                   (OXFORD)
LEWIS    73 NP B 60 283          +ALLEN,JACOBS,DANYSZ,BORG,+(LOWC+LOIC+CDEF)
LINGLIN  73 NP B 55 408          D.LINGLIN                            (CERN)
WALUCH   73 PR D 8 2837          +FLATTE,FRIEDMAN                      (LBL)

FOX      74 NP B80 403           G.C.FOX,M.L.GRISS            /        (CIT)
MATISON  74 PR D9 1872           +GALTIERI,GARNJOST,FLATTE,FRIEDMAN,+  (LBL)

BRANDENB 75 PL 59 B 405          BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)
CARITHER 75 PRL 35 349           CARITHERS,MUHLEMANN,UNDERWOOD,+ (ROCH+MCGI)
MCCUBBIN 75 NP B86 13            N.A.MCCUBBIN,L.LYONS                  (OXF)
PALER    75 NP B96 1             +TOVEY,SHAH,SPIRO,CHAURAND+(RHEL+SACL+EPOL)


KIRK     76 NP B 116 99          +KLEIN,COUNIHAN,+(AACH+BERL+CERN+LOIC+WIEN)
BOWLER   77 NP B 126 31          +DAINTON,DRAKE,WILLIAMS            (OXFORD)

AGUILAR  78 NP B 141 101         +FERNANDEZ,COOPER,+   (MADR+TATA+CERN+CDEF)
BALAND   78 NP B 140 220         +GRARD,JOHNSON,+ (MONS+BELG+CERN+LOIC+LALO)
BALDI    78 NP B 134 365         +BOHRINGER,DORSAZ,HUNGERBUHLER+      (GEVA)
COOPER   78 NP B 136 365         +GURTU,DOBRZYNSKI,+   (TATA+CERN+CDEF+MADR)
ENGELEN  78 NP B 134 14          +JONGEJANS,HEMINGWAY,+ (NIJM+ZEEM+CERN+OXF)
ESTABROC 78 NP B 133 490         ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)
    ALSO 78 PR D 17 658          ESTABROOKS,CARNEGIE+  (MONT+CARL+DURH+SLAC)
JONGEJAN 78 NP B 139 383         JONGEJANS,CERRADA,+    (ZEEM+CERN+NIJM+OXF)

MARTIN   78 NP B 134 392         +SHIMADA,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)
WICKLUND 78 PRD 17 1197          +AYRES,DIEBOLD,GREENE,KRAMER,PAWLICKI (ANL)

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Q REGION, $K\pi\pi(1200-1400)$

28 Q REGION (1200-1400) I=1/2

The main effect in the Q region is a broad bump in the $K\pi\pi$ spectrum between 1200 and 1400 MeV (not far above the $K^*(892)\pi$ threshold), produced by K beams without charge exchange. In particular, it has been observed in coherent K^+d interactions (FIRESTONE 72) and in coherent interactions on heavy nuclei (BINGHAM 73). Throughout the entire region, $J^P = 1^+$ and $I = 1/2$. FIRESTONE1 72 observe a bump in the backward direction with a shape similar to that of the Q. The broad Q peak does not have a simple Breit-Wigner shape. It can be fitted at all energies by a superposition of two Breit-Wigner amplitudes. Dalitz plot analyses of the interference between the $K^*\pi$ and $K\rho$ modes show the relative magnitude and relative phase of the two decay amplitudes varying with $K\pi\pi$ mass. The $K\rho$ mode has a maximum intensity below that of $K^*\pi$.

Partial-wave analyses have confirmed the rather complex situation in the Q region (DEUTSCHMANN 74, ANTIPOV 75, OTTER 75,76, TOVEY 75, BRANDENBURG 76, BEUSCH 78, VERGEEST 79). The dominant states are 1^+S $(K^*\pi)$, almost entirely $I = 1/2$ (VERGEEST 79), and 1^+S $(K\rho)$. Other important states are $J^P = 0^-$ and $J^P = 2^+$. The $K^*\pi$ and $K\rho$ modes are not produced coherently and have different polarization properties (BRANDENBURG 76, OTTER 76, VERGEEST 79). Whereas the $K\rho$ mode approximately conserves s-channel helicity, the $K^*\pi$ mode is approximately t-channel helicity conserving.

Experimentally, those data with sufficient statistics show the presence of a two-peak structure (OTTER 76, BRANDENBURG 76). BRANDENBURG 76 claim to observe sufficient phase variation to warrant proposing the existence of two $J^P = 1^+$ $K\pi\pi$ resonances: Q_1, with a mass around 1280 MeV, a width of the order of 150 MeV, and mainly coupled to the $K\rho$ channel; and Q_2, with a mass around 1400 MeV, a width of the order of 150 MeV, and mainly coupled to the S-wave $K^*\pi$ channel (CARNEGIE 77). These results are experimentally confirmed by VERGEEST 79 and supported by the BOWLER 77 and BASDEVANT 79 analyses.

Data Card Listings

For notation, see key at front of Listings.

Mesons

Q

AACHEN 76 and WOHL 78 have shown some evidence for a Kω decay of the Q_1 in diffraction-like processes.

The $(K\pi\pi)^0$ system produced in the charge-exchange reaction appears to have an important $J^P = 1^+$ contribution (OTTER1 75, VERGEEST 76). The $1^+(K^*\pi)$ and $1^+(K\rho)$ waves cannot be explained as decay products of a single resonance and the $K^*\pi$ wave behavior suggests a resonance contribution around 1400 MeV (VERGEEST 76).

There are a number of claims for the observation of $K\pi\pi$ resonances in the Q mass region in other non-diffractive processes (ARMENTEROS 64, CRENNEL 67,72, ASTIER 69, DAVIDSON 74, DORE 75). These data can be described in terms of a single resonance of characteristics consistent with those of the Q_1 (CONFORTO 77). A result from the hyperon-exchange reaction (GAVILLET 78) again shows the production of a $J^P = 1^+$ Kρ resonance with mass and width close to those of the Q_1. Neither ARMENTEROS 64 (nor a later analysis by ASTIER 69) nor GAVILLET 78 observe a $K^*\pi$ resonance compatible with the Q_2. However the assignment to a $J^{PC} = 1^{++}$ SU(3) nonet of the $J^P = 1^+$ Kρ resonance together with the A_1, D(1285), and E(1420) seems to support the existence of a $Q_2(1400)$ with parameters compatible with those of CARNEGIE1 77 (MAZZUCATO 79 and DIONISI 80).

Note that IRVING 80 discusses a model for non-diffractive Q production in which the Q_2 is suppressed relative to the Q_1.

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                    28   Q REGION MASS   (MEV)

M    PRODUCED BY BEAMS OTHER THAN K MESONS
M  A        1242.0        9.0        10.0    ASTIER     69 HBC     0 PBAR P          . 9/69
M  A     THIS IS THE C MESON.
M         45(13C0.)                          CRENNELL   67 HBC     0 6 PI- P,LK2PI    7/67
M         40(1300.)                          CRENNELL   72 HBC     0 4.5PI-P,LK2PI   12/72
M         40(1278.)      (5.)                DAVIDSON   74 HBC   +- 1.6-2.2 PBAR P   12/75
M         43(1235.)     (10.)                DORE       75 OSPK    06.2 PI-P,L MM    12/75

M    PRODUCED BY K-, BACKWARDS SCATTERING, HYPERCN EXCHANGE
M  C     700 1275.0       10.0               GAVILLET   78 HBC   +  4.2 K-P,XI-KPIPI  4/78*
M  C       COUPLES MAINLY TO RHO K.

M    PRODUCED BY K BEAMS
M         12(1320.0)    (25.0)               ALMEIDA    65 HBC   +    3-5 K+  P      12/72
M   C       (1230.0)    (15.0)               BASSOMPIE  67 HBC   +    5. K+ P        11/67
M   C     35(1280.0)    (10.0)               BASSOMPIE  67 HBC   +    5. K+ P        11/67
M   C       (1320.0)    (15.0)               BASSOMPIE  67 HBC   +    5. K+ P        11/67
M   C     SPLIT THE Q REGION INTO 3 BUMPS
M           (1270.)    APPROX.               DE BAERE   67 HBC   +    3.5 K+ P        7/67
M           (1335.0)     (6.0)               BARTSCH    68 HBC        10. K-P,K NPI  .12/75
M           (1300.)    APPROX.               BARBARO    69 HBC   +    12.K+ P (K 2PI)  9/69
M         45(1301.0)    (10.0)               BISHOP     69 HBC   +    3.5 K+P(K* PI) 12/75
M         21(1300.0)    (10.0)               ERWIN      69 HBC     0 3.5 K+P(K* PI)  12/75
M           (1281.)      (7.)                FRIEDMAN   69 HBC   -    2.6,2.7 K- P   12/75
M           (1300.0)    (10.0)               ABRAMS     70 HBC   +    2.5-3.2 K+ P   12/75
M           (1260.)     (20.)                FARBER     70 HBC   +    12.7 K+ P     .12/75
M           (1325.0)                         DENEGRI    71 DBC    - 12.6 K-D,K 2PI D 12/75
M           (1296.)      (5.)                BARLOUTAU  73 HBC   -  14.3 K-P,P K-2PI 12/75
M           (1283.)      (6.)                BARLOUTAU  73 HBC   -  14.3 K-P,P K02PI 12/75
M           (1315.)      (7.)                BINGHAM    73 HLBC  -  5.5-12.7 CCH K-A 12/75
M           (1260.)     (10.)                LEWIS      73 HBC   +  2.1-2.7 K+ P     12/75
M           (1260.)      (5.)                LEWIS      73 HBC   +  2.1-2.7 K+ P     12/75

M    AVERAGING NOT MEANINGFUL

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                    28   Q LOW (Q1)   MASS   (MEV)

ML        FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS
ML
ML          (1280.)                          SHEN       66 HBC   + 0 4.6 K+P,5 BODY  12/72
ML          (1260.0)    (10.0)               ALEXANDER  69 HBC       9.0 K+ P        12/75
ML          (1240.0)     (5.0)               BARNHAM    71 HBC   +  10.0 K+P,K 2PI   12/75
ML          (1243.)      (8.)                GARFINKEL  71 DBC   +  9. K+ D          12/75
ML          (1228.)     (14.)                ANDERSON   72 DBC   -  7.3 K- D         12/75
ML          (1260.)                          DAVIS      72 HBC   +  12. K+ P         12/72
ML          (1234.)     (12.)                FIRESTONE  72 DBC   +  12. K+ D          2/73
ML C        (1300.)    APPROX.               BRANDENB   76 ASPK +- 13 K+-P,(KPIPI)P 12/75
ML  E       (1289.0)    (25.0)               CARNEGIE   77 ASPK +- 13 K+-P,P KPIPI   12/77
ML          (1270.0)   APPROX.               OTTER      76 HBC   - 10-14-16K-P       12/77
ML          (1300.0)   APPROX.               VERGEEST   79 HBC  +- 4.2 K-P,K PI PI   12/79*
ML
ML C      COUPLES MAINLY TO RHO K
ML  E     FROM A MODEL DEPENDENT FIT WITH GAUSSIAN BACKGROUND TO
ML  E     BRANDEMBURG 76 DATA.

ML   AVERAGING NOT MEANINGFUL

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                    28   Q HIGH (Q2)   MASS   (MEV)

MH        FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS
MH
MH        70(1320.0)    (10.0)               SHEN       66 HBC   +    4.6 K+  P      12/75
MH          (1380.0)    (20.0)               ALEXANDER  69 HBC       9.0 K+ P        12/75
MH          (1420.0)     (5.0)               BARNHAM    71 HBC   +  10.0 K+P,K 2PI   12/75
MH          (1344.)      (8.)                GARFINKEL  71 DBC   +  9. K+ D          12/75
MH          (1414.)     (15.)                ANDERSON   72 DBC   -  7.3 K- D         12/75
MH          (1420.)                          DAVIS      72 HBC   +  12. K+ P         12/72
MH          (1368.)     (18.)                FIRESTONE  72 DBC   +  12. K+ D         12/77
MH D        (1400.)    APPROX.               BRANDENB   76 ASPK +- 13 K+-P,(KPIPI)P 12/75
MH  E       (1404.0)    (10.0)               CARNEGIE   77 ASPK +- 13 K+-P,P KPIPI   12/77
MH          (1400.0)   APPROX.               VERGEEST   79 HBC  +- 4.2 K-P,K PI PI   12/79*
MH
MH D      COUPLES MAINLY TO K* PI
MH  E     SEE NOTE E ABOVE.
MH
MH   AVERAGING NOT MEANINGFUL

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                    28   Q REGION WIDTH   (MEV)

W    PRODUCED BY BEAMS OTHER THAN K MESONS
W           127.0        7.0        25.0     ASTIER     69 HBC     0 PBAR P          . 9/69
W      45   (60.)                            CRENNELL   67 HBC     0 6 PI- P          7/67
W      40   (60.)                            CRENNELL   72 HBC     0 4.5PI-P,LK2PI   12/72
W  D   40   (25.)       (15.)                DAVIDSON   74 HBC   +- 1.6-2.2 PBAR P   12/75
W  D    ERROR INCREASED BY US. SEE K* TYPED NOTE.
W      43   (30.)       (25.)       (18.)    DORE       75 OSPK    06.2 PI-P,L MM    12/75

W    PRODUCED BY K-, BACKWARDS SCATTERING, HYPERON EXCHANGE
W  C   700    75.0       15.0                GAVILLET   78 HBC   +  4.2 K-P,XI-KPIPI  4/78*
W  C     COUPLES MAINLY TO RHO K.

W    PRODUCED BY K BEAMS
W      12   (60.0)      (20.0)               ALMEIDA    65 HBC   +    3-5 K+P        12/72
W   C       (60.0)      (20.0)               BASSOMPIE  67 HBC   +    5. K+ P        11/67
W   C  35   ( 80.0)     (20.0)               BASSOMPIE  67 HBC   +    5. K+ P        11/67
W   C       (60.0)      (20.0)               BASSOMPIE  67 HBC   +    5. K+ P        11/67
W   C   SPLIT THE Q REGION INTO 3 BUMPS
W          (200.)     APPROX.                DE BAERE   67 HBC   +  3.5 K+ P          7/67
W          (196.0)      (16.0)               BARTSCH    68 HBC      10. K- P,K NPI  .12/75
W   B       250.  APPROX.                    BARBARO    69 HBC   +    12.K+ P (K 2PI)  9/69
W   B      NO BACKGROUND SUBTRACTION.
W      45   (40.0)      (10.0)               BISHOP     69 HBC   +    3.5 K+P(K* PI) 12/75
W      21   (40.0)      (15.0)               ERWIN      69 HBC     0 3.5 K+P(K* PI)  12/75
W           (51.)       (22.)                FRIEDMAN   69 HBC   -    2.6,2.7 K- P   12/75
W           (80.0)      (20.0)               ABRAMS     70 HBC   +    2.5-3.2 K+ P   12/75
W          (180.)       (28.)                FARBER     70 HBC   +    12.7 K+ P     .12/75
W          (180.0)                           DENEGRI    71 DBC    - 12.6 K-D,K 2PI D  5/71
W          (326.)       (17.)                BARLOUTAU  73 HBC   -  14.3 K-P,P K-2PI 12/75
W          (266.)       (21.)                BARLOUTAU  73 HBC   -  14.3 K-P,P K02PI 12/75
W          (150.)       (70.)                LEWIS      73 HBC   +  2.1-2.7 K+ P     12/75
W           (47.)       (18.)                LEWIS      73 HBC   +  2.1-2.7 K+ P     12/75

W    AVERAGING NOT MEANINGFUL

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                    28   Q LOW (Q1)   WIDTH   (MEV)

WL F      FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS
WL
WL          (100.0)     (20.0)               SHEN       66 HBC   + 0 4.6 K+P,5 BODY  12/75
WL           (40.0)     (10.0)               ALEXANDER  69 HBC       9.0 K+ P        12/75
WL          (110.0)     (15.0)               BARNHAM    71 HBC   +  10.0 K+P,K 2PI   12/75
WL           (70.)      (26.)      (18.)     GARFINKEL  71 DBC   +  9. K+ D          12/75
WL          (111.)      (33.)                ANDERSON   72 DBC   -  7.3 K- D         12/75
WL          (120.)                           DAVIS      72 HBC   +  12. K+ P         12/72
WL          (188.)      (21.)                FIRESTONE  72 DBC   +  12. K+ D         12/75
WL C        (200.)     APPROX.               BRANDENB   76 ASPK +- 13 K+-P,(KPIPI)P 12/75
WL  E       (150.00)   (71.0)                CARNEGIE   77 ASPK +- 13 K+-P,P KPIPI   12/77
WL          (150.0)    APPROX.               VERGEEST   79 HBC  +- 4.2 K-P,K PI PI   12/79*
WL
WL C      COUPLES MAINLY TO RHO K
WL  E     SEE NOTE E ABOVE.

WL   AVERAGING NOT MEANINGFUL

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                    28   Q HIGH (Q2)   WIDTH   (MEV)

WH F      FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS
WH
WH        70  (80.0)    (20.0)               SHEN       66 HBC   +    4.6 K+P        12/75
WH          (120.0)     (20.0)               ALEXANDER  69 HBC       9.0 K+ P        12/75
WH          (120.0)     (15.0)               BARNHAM    71 HBC   +  10.0 K+P,K 2PI   12/75
WH           (60.)     OR LESS               GARFINKEL  71 DBC   +  9. K+ D          12/72
WH           (89.)      (24.)                ANDERSON   72 DBC   -  7.3 K- D         12/75
WH           (80.)                           DAVIS      72 HBC   +  12. K+ P         12/72
WH          (241.)      (30.)                FIRESTONE  72 DBC   +  12. K+ D         12/75
WH D        (160.)     APPROX.               BRANDENB   76 ASPK +- 13 K+-P,(KPIPI)P 12/75
WH  E       (142.0)     (16.0)               CARNEGIE   77 ASPK +- 13 K+-P,P KPIPI   12/77
WH          (200.0)    APPROX.               VERGEEST   79 HBC  +- 4.2 K-P,K PI PI   12/79*

WH D      COUPLES MAINLY TO K* PI
WH  E     SEE NOTE E ABOVE.

WH   AVERAGING NOT MEANINGFUL

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Mesons

Q, K′(1400)

Data Card Listings

For notation, see key at front of Listings.

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                    28  Q REGION PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      Q REGION INTO K*(892) PI                        892+ 139
P2      Q REGION INTO K RHO                             497+ 776
P3      Q REGION INTO K PI                              497+ 139
P4      Q REGION INTO K ETA                             497+ 548
P5      Q REGICN INTO K CMEGA                           497+ 782
P6      Q REGION INTO K PI PI                           497+ 139+ 139

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                    28  Q REGION PARTIAL WIDHTS (MEV)

W    PRODUCED BY K-, BACKWARDS SCATTERING, HYPERON EXCHANGE
W
W1      C INTO K RHO                                    (G1)
W1            57.0      5.0          MAZZUCATO 79 HBC   +  4.2 K-P,XI-KPIPI 12/79*
W2      C INTO K* PI                                    (G2)
W2            14.0      11.0         MAZZUCATO 79 HBC   +  4.2 K-P,XI-KPIPI 12/79*
W3      C INTC K OMEGA                                  (G3)
W3             4.0      4.00         MAZZUCATO 79 HBC   +  4.2 K-P,XI-KPIPI 12/79*
W
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                    28  Q LOW (Q1) PARTIAL WIDTHS (MEV)

WL        FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS
WL
WL1     Q1 INTO K RHO                                   (G1)
WL1           75.0      6.0          CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78*
WL2     Q1 INTO K* PI                                   (G2)
WL2            2.0      2.0          CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78*
WL3     Q1 INTO K OMEGA                                 (G3)
WL3           24.0      3.0          CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78*
WL4     Q1 INTC KAPPA PI                                (G4)
WL4           26.0      6.0          CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78*
WL5     Q1 INTO EPSILON K                               (G5)
WL5           22.0      5.0          CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78*
WL
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                    28  Q HIGH (Q2) PARTIAL WIDTHS (MEV)

WH        FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS
WH
WH1     Q2 INTO K RHO                                   (G1)
WH1            2.0      1.0          CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78*
WH2     Q2 INTO K* PI                                   (G2)
WH2          117.0      10.0         CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78*
WH3     Q2 INTC K CMEGA                                 (G3)
WH3           23.0      12.0         CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78*
WH
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                    28  Q REGICN BRANCHING RATIOS

   PRODUCED BY BEAMS OTHER THAN K MESONS
R1      Q REGICN INTO (K RHC)/TOTAL (UNITS OF 10**-2)   (P2)
R1            75.0      10.0         ARMENTERO 64 HBC      0.0 PBAR P       6/66
R1          DCMINANT                 CRENNELL  72 HBC    0 4.5PI-P,LK2PI   12/72

R2      Q REGION INTO (K* PI)/TOTAL (UNITS OF 10**-2)   (P1)
R2            25.0      10.0         ARMENTERO 64 HBC      0.0 PBAR P       6/66

R4      Q REGICN INTO (KO PI+ PI- PIO) / (K+0 PIO+ PI-)
R4           (0.1)  OR LESS  CL=.90  CRENNELL  67 HBC    0 6.0 PI-P         7/67

   PRODUCED BY K BEAMS
R11     Q REGION INTO (K OMEGA)/(K*(892) PI)            (P5)/(P1)
R11          (0.1)  OR LESS          SHEN      66 HBC   +  4.6 K+P         10/66

R13     Q REGICN INTO K*(892) PI AND K RHO (OVERLAPPING BANDS)
R13                                                     (P1+P2)
R13     200   (1.0)                  BERLINGHI 67 HBC   +  12.7 K+ P        7/67

R15     Q REGION INTO (K ETA) / TOTAL                   (P4)
R15          (0.02) OR LESS          BERLINGHI 67 HBC   +  12.7 K+ P       11/67

R16     Q REGICN INTO (K OMEGA) / TOTAL                 (P5)
R16          (0.02) OR LESS          BERLINGHI 67 HBC   +  12.7 K+ P       11/67
R16      12    0.01      0.005       BARTSCH   68 HBC   -  10.0 K- P        9/68

R17     Q REGION INTO (K RHO) / (K*(892) PI)            (P2)/(P1)
R17            0.91      0.25        BERLINGHI 67 HBC   +  12.7 K+ P       11/67
R17     701    0.4       0.1         BARTSCH   68 HBC   - 10.0 K- P         9/68
R17            . . . . . . . . . .
R17 AVG        0.47      0.18    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
R17 STUDENT    0.46      0.11    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R19     Q REGION INTO (K PI PI) / TOTAL                 (P6)
R19     201    0.22      0.08        BARTSCH   68 HBC   - 10.0 K- P         9/68
R19  S      PCSSIBLY SEEN            ALEXANDER 69 HBC      9.0 K+ P         2/73
R19  S      POSSIBLY SEEN            DAVIS     72 HBC   + 12. K+ P          1/73
R19  S  WITH THE (PI PI) SYSTEM IN S-WAVE

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REFERENCES FOR Q REGION


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ARMENTER 64 DUBNA CONF 1 577  ARMENTEROS,EDWARDS,D-ANDLAU +    (CERN+CDEF)
    ALSC 64 CUBNA CONF 1 617  R ARMENTEROS (RAPPORTEUR)
ARMENTER 64 PL 9 207          ARMENTEROS,EDWARDS,D-ANDLAU,+    (CERN+CDEF)
    ALSO 66 PR  145  1095     BARASH,KIRSCH,MILLER,TAN          (COLUMBIA)
ALMEIDA  65 PL 16 184         ALMEIDA,ATHERTON,BYER,DORNAN,FORSON+ (CAVE)
SHEN     66 PRL  17  726      +BUTTERWORTH,FU,GOLDHABERS,TRILLING    (LRL)
    ALSO 66  (PRIVATE COMMUN)GERSON GOLDHABER                        (LRL)

BASSOMPI 67 PL 26B 30         BASSOMPIERRE,GOLDSCHMIDT+  (CERN+BRUX+BIRM)IJP
BERLINGH 67 PRL 18 1087       BERLINGHIERI+FARBER+FERBEL+FORMAN    (ROCH)IJP
CRENNELL 67 PRL 19  44        +KALBFLEISCH,LAI,SCARR,SCHUMANN       (BNL)I
DE BAERE 67 NC 49A 374        +DEBAISIEUX+FAST+FILIPPAS+       (CERN+BRUX)
    ALSO PRIVATE COMMUNICATION BY B. JONGEJANS
GOLDHABE 67 PRL 19 976        G.GOLDHABER                            (LBL)

BARTSCH  68 NP B8 9           +COCCONI,+        (AACH+BERL+CERN+LOIC+VIEN)
BOMSE    68 PRL 20 1519       +BORENSTEIN,CALLAHAN,COLE,COX,+ (JOHNHOPK)  1+
DENEGRI  68 PRL 20 1194       +CALLAHAN+ETTLINGER+GILLESPIE+  (JOHNHCPK)  1+
    ALSO 70 ANTICH
ALEXANDE 69 NP B 13 503       G.ALEXANDER,FIRESTONE,GOLDHABER,+      (LRL)
ANDREWS  69 PRL 22 731        +LACH,LUDLAM,SANDWEISS,BERGER,+  (YALE+LRL)
ASTIER   69 NP B 10 65        +MARECHAL,MCNTANET,+  (CDEF+CERN+IPNP+LIVP)IJP
BARBARO  69 PRL 22 1207       BARBARO-GALTIERI,DAVIS,FLATTE,+        (LRL)
BETTINI  69 NC 62 A 1038      +CRESTI,LIMENTANI,BERTAUZA,BIGI+(PADO+PISA)I
BISHOP   69 NP B 9 403        +GOSHAW,ERWIN,WALKER                  (WISC)
CHIEN    69 PL 29B 433        +MALAMUD,MELLEMA,RUDNICK,SCHLEIN+     (UCLA)
CHUNG    69 PR 182 1443       +EISNER+BALI+LUERS                     (BNL)
COLLEY   69 NC A 59 519       +EASTWOOD,+  (BIRM+GLAS+LOIC+MPIM+OXF+RHEL)
ERWIN    69 NP B 9 364        +WALKER,GOSHAW,WEINBERG    (WISC+PRIN+VAND)
FRIEDMAN 69  UCRL-18860       J.FRIEDMAN,PH.D. THESIS                (LRL)
WERNER   69 PR 188 2023       +AMMAR,DAVIS,KROPAC,YARGER,CHO,+ (NWES+ANL) 1+

ABRAMS   70 PR D 1 2433       +EISENSTEIN,KIM,MARSHALL,O-HALLORAN,+ (ILL)
ANTICH   70 NP B 20 201       +CARSON,CHIEN,COX,DENEGRI,ETTLINGER,+ (JHU)  1+
BOWLER   70 PL 31 B 318       M.G.BOWLER                          (OXFORD)
FARBER   70 PR D 1 78         +FERBEL,SLATTERY,YUTA                 (RCCH)  1+

BARNHAM  71 NP B25 49         +COLLEY,GRIFFITHS,ALPER, +   (BIRM+GLAS+OXF)
DENEGRI  71 NP B 28 13        +ANTICH,CALLAHAN,CARSON,CHIEN,COX,+   (JHU)  1+
FORMAN   71 PR D 3 2610       +GELFAND,LEARY,MOSER,SEIDL,WOLFSON    (EFI)
GARFINKE 71 PRL 26 1505       GARFINKEL,HOLLAND,CARMONY,LANDER+(PURD+UCD)  1+

ANDERSON 72 PR D 6 1823       +FRANKLIN,GODDEN,KOPELMAN,LIBBY,TAN  (COLO)
BINGHAM  72 NP B 48 589       +EISENSTEIN,GRARD,HERQUET,+     (CERN+BRUX)
BRANDENB 72 NP B 45 397       BRANDENBURG,BRODY,JOHNSON,LEITH,LOOS+(SLAC)
BRANDENB 72 PRL 28 932        BRANDENBURG,JOHNSON,LEITH,LOOS,LUSTE+(SLAC)
CRENNELL 72 PR D 6 1220       +GORDON,KWAN-WU LAI,SCARR              (BNL)
DAVIS    72 PR D 5 2688       +ALSTCN,BARBARO,FLATTE,FRIEDMAN,LYNCH+(LBL)
FIRESTON 72 PR D 5 505        FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)
FIRESTON172 NP B 47 348       A.FIRESTONE                            (CIT)
FRATI    72 PR D 6 2361       +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
HAATUFT  72 NP B 48 78        +ARNOLD,HAGUENAUER,+  (BERG+STRB+EPOL+MADR)

BARLOUTA 73 NP B 59 374       +DREVILLCN,SHAH,+          (SACL+EPOL+RHEL)  JP
BINGHAM  73 NP B 52 31        +FARWEL,+       (LBL+ORSAY+BNL+SACLAY+MILAN)  JP
DE JONGH 73 NP B 58 110       +CORNET,CHARRIERE,+   (BRUX+MONS+CERN+MPIM)
JCNES    73 NP B 52 383       G.T.JCNES                             (CERN)  JP
LEWIS    73 NP B 6C 283       +ALLEN,JACCBS,DANYSZ,BORG,+(LOWC+LOIC+CDEF)
WERNER   73 PR D 7 1275       +SLATTERY,FERBEL                 (ROCHESTER)

ANGELOPO 74 NC 20A 49         ANGELOPOULCS,FILIPPAS+(ATHU+ATEN+LIVP+VIEN)  JP
BOWLER   74 NP B74 493        +DAINTON,KADDOURA,AITCHISON            (CXF)
DAVIDSON 74 PR D9 77          +CHAPMAN,GREEN,LYS,ROE                 (MICH)
DEUTSCHM 74 PL 49B 388        DEUTSCHMANN,+     (AACH+BERL+CERN+LOIC+VIEN)  JP

ANTIPOV  75 NP B86 381        +ASCOLI,BUSNELLO,KIENZLE+    (SERP+CERN+ILL)  JP
BOWLER   75 NP B97 227        +GAME,AITCHISON,DAINTON            (OXF+DARE)
DORE     75 LNC 13 265        +GUIDONI,LAAKSO,MARINI,CONFORTO+(ROMA+RHEL)
DREVILLO 75 PL 55 B 245       DREVILLON,BORENSTEIN+       (EPCL+BOHR+CDEF)  JP
DUNWOODI 75 NP B91 189        DUNMOODIE,GRANT+       (CERN+BELG+MONS+MPIM)  JP
OTTER1   75 NP B84 333        + (AACH+BERL+CERN+LOIC+VIEN+ATHU+ATEN+LIVP)  JP
OTTER2   75 NP B93 365        +RUDOLPH,RUMPF+  (AACH+BERL+CERN+LOIC+VIEN)  JP
OTTER3   75 NP B96 29         +RUDOLPH,SEYFERT+(AACH+BERL+CERN+LOIC+VIEN)I,JP
TOVEY    75 NP B95 109        +HANSEN,BORENSTEIN,BORG+   (RHEL+EPOL+SACL)I,JP

BASDEVAN 76 PRL 37 977        BASDEVANT,BERGER                   (FNAL+ANL)
BOAL     76 PR D 14 2998      +EDWARDS,KAMAL,TORGESON              (ALBERTA)
BOWLER   76 JPG 3 775         M.G.BOWLER                           (OXFCRD)
BRANDENB 76 PRL 26 703        BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)  JP
OTTER    76 NP B 106 77       + (AACH+BERL+CERN+LOIC+VIEN+LPNP+RHEL+SACL)  JP
VERGEEST 76 PL 62 B 471       +ENGELEN,JCNGEJANS,+    (AMST+CERN+NIJM+CXF)  JP

CARNEGIE 77 NP B 127 509      +CASHMORE,DAVIER,DUNWOODIE,LASINSKI+ (SLAC)
CARNEGIE177 PL B 68 287       +CASHMORE,DUNWOODIE,LASINSKI,+        (SLAC)
CHEN     77  ANL HEP PR 77 22 +FIELDS,RHINES                        (ANL)
CONFORTO 77  RL-77-024/A      B.CONFORTO AND G.CONFORTO        (ROMA+RHEL)

BEUSCH   78 PL 74 B 282       +BIRMAN,KONIGS,OTTER,+      (CERN+AACH+ETH)  JP
GAVILLET 78 PL 76 B 517       +DIAZ,DIONISI,+        (AMST+CERN+NIJM+OXF)  JP
WOHL     78 NP B 132 401      +PALER,CHAURAND,+         (LPNP+RHEL+SACLAY)

BASDEVAN 79 PR D 19 246       BASDEVANT,BERGER                       (ANL)
MAZZUCAT 79 NP B 156 532      MAZZUCATO,PENNINGTON+  (CERN+ZEEM+NIJM+OXF)
VERGEEST 79 NP B 158 265      +JONGEJANS,DIONISI,+   (NIJM+AMST+CERN+CXF)

DIONISI  80  CERN/EP 80-1     +GAVILLET,ARMENTEROS+ (CERN+MADR+CDEF+STOH)
IRVING   80 JPG 6 153         A.C.IRVING                            (LIVP)
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K′(1400) →

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21  K PRIME(1400,JP=0-) I=1/2

OBSERVED IN K PI PI PARTIAL-WAVE ANALYSIS.
WAIT CONFIRMATION. OMITTED FROM TABLE.

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                    21  K PRIME MASS (MEV)

M  A       (1400.)   APPROX.         BRANDENBU 76 ASPK +- 13 K+-P,KPIPI     12/77
M  A      COUPLED MAINLY TO K EPSILON. DECAY INTO K*(890) PI SEEN.
M

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                    21  K PRIME WIDTH (MEV)

W  A        (250.)   APPROX.         BRANDENBU 76 ASPK +- 13 K+-P,KPIPI     12/77
W  A      COUPLED MAINLY TO K EPSILON. DECAY INTO K*(890) PI SEEN.
W

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REFERENCES FOR K PRIME


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BRANDENB 76 PRL 36 1239       BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)  JP
AACHEN   77  PREP. AACHEN 41  +         (AACHEN+BERLIN+CERN+LOIC+VIENNA)  JP
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Data Card Listings

For notation, see key at front of Listings.

K*(1430)

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22  K*(1430,JP=2+) I=1/2

WE CONSIDER THAT PHASE-SHIFT ANALYSES PROVIDE MORE
RELIABLE DETERMINATIONS OF THE MASS AND WIDTH.
SEE RHO(770) MINI-REVIEW.
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22  K*(1430) MASS (MEV)

M   CHARGED ONLY, WITH FINAL STATE K PI
M    D  39 1423.       11.0              BASSANO   67 HBC   - 4.6-5.0K-P,KOPI- 12/75
M   S   25(1440.)     (24.0)   (40.)     DE BAERE  67 HBC  +  3.5 K+P (K+ PIO) 12/75
M   SD  13(1401.0)    (25.0)             SCHWEINGR 68 HBC  -   4.1 K- P (K PI) 12/75
M    D  63 1427.0      12.0              SCHWEINGR 68 HBC  -   5.5 K- P (K PI) 12/77
M   S  136(1420.0)    (20.0)             BISHOP    69 HBC  +   3.5 K+P(KO PI+) 12/77
M      220 1416.0      10.0              CRENNELL  69 DBC  -   3.9 K-N (KOPI-)  7/69
M    D  60 1414.       13.0              LIND      69 HBC  +   9. K+ P(KO PI+) 12/77
M     1400 1420.0       3.1              AGUILAR1  71 HBC  -   3.9,4.6 K- P    11/71
M  W D 225 1425.        8.0              BARNHAM   71 HBC  +  K+ P,KO PI+ P    12/75
M      130(1418.)      (6.)              CLARK     73 HBC  -  3.3 K-P,P PI- KO 12/77
M   S     (1425.9)     (6.2)             MARTIN    78 SPEC +- 10 K+-P,KS PI P  12/78*
M          . . . . . . . . .
M   AVG     1420.5      2.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1420.5       2.8     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M   CHARGED ONLY, WITH OTHER FINAL STATES
M      130(1400.0)    (20.0)             BADIER    65 HBC  -  3.  K- P (K*PI) 12/75
M       20(1440.0)    (20.0)             DUBAL     68 MMS  -  11.5 K- P        12/75
M  W D 240(1396.)      (6.)              BASSOMPIE 69 HBC  +   5 K+P (K 2PI)   12/75
M         (1411.)      (7.)              FRIEDMAN  69 HBC  -   2.7 K-P (K 2PI)  2/72

M   CHARGED AND NEUTRAL
M      134(1404.0)    (15.0)             FOCARDI   65 HBC  -0 3.  K- P (K PI) 12/75
M    D  55(1423.)     (24.0)             ADERHOLZ  68 HBC  -0 10 K- P (K PI)  12/75

M   NEUTRAL ONLY
M    D  46(1446.0)     (9.0)             DAHL      67 HBC   0 4.PI- P (KPI)    12/77
M   S  160(1425.0)    (15.0)             KANG      68 HBC   0 4.6 K- P         12/75
M   SD  81(1405.0)    (22.0)             SCHWEINGR 68 HBC   0 4.1 K- P (K PI) 12/75
M   S   97(1397.0)    (19.0)             SCHWEINGR 68 HBC   0 5.5 K- P (K PI) 12/75
M  WAD 210(1422.)      (8.0)             BASSOMPIE 69 HBC   0 5 K+P (K PI)     12/75
M     2200 1421.1       2.6              DAVIS     69 HBC   0 12. K+ P(K+PI-)   9/69
M     1800 1419.1       3.7              AGUILAR1  71 HBC   0 3.9,4.6 K- P     11/71
M      600 1416.        6.               CORDS     71 DBC  0 9. K+ N,K+ PI- P   2/72
M     1100 1427.        3.               BUCHNER   72 DBC  0 4.6 K+ N,K+ PI-P 12/72
M    C      1420.1      4.3              LINGLIN   73 HBC  0 2-13 K+P,K+PI-    12/75
M      800 1421.6       4.2              MCCUBBIN  75 HBC   0 3.6 K-P,K-PI+N   12/75
M           1423.0      3.0              ETKIN     76 SPEC  06.K-P,KO PI+PI-    7/77
M      300 1420.0       7.0              HENDRICKX 76 DBC     8.25 K+N,K+PI     7/77
M  P        1440.0     10.0              BOWLER    77 DBC  0 5.5 K+D,K PI P P 12/77
M  P        1434.0      2.0              ESTABROOK 78 ASPK 0 13K+-P,P K PI     12/77
M          . . . . . . . . .
M   AVG     1425.7      2.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
M   STUDENT1423.7       1.5     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                               (SEE IDEOGRAM BELOW )

M   A   INCLUDED IN LINGLIN 73 WORLD K+P DST
M    C  FROM POLE EXTRAPOLATION, USING WORLD K+P DST
M    D  ERRORS ENLARGED BY US TO   GAMMA/SQRT(N). SEE TYPED NOTE ON K*
M  P    FROM PHASE SHIFT ANALYSIS.
M   S   DATA WITH MASS ERROR OF 15 MEV OR MORE NOT AVERAGED
M  W    NUMBER OF EVENTS IN PEAK REEAVALUATED BY US
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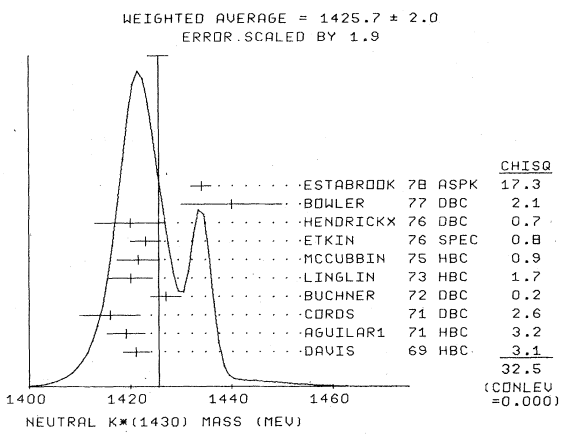


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22  K*(1430) WIDTH (MEV)

W   CHARGED ONLY, WITH FINAL STATE K PI
W    D  63    89.       45.                SCHWEINGR 68 HBC   - 5.5 K-P(KO PI-)   12/75
W   SD 136  (110.0)    (42.0)              BISHOP    69 HBC  +   3.5 K+ P         12/75
W    D  60    96.       50.0               LIND      69 HBC  +   9. K+ P          .12/77
W     1400    94.7      15.1      12.5     AGUILAR1  71 HBC  -   3.9,4.6 K- P     11/71
W  W D 225   115.       31.0               BARNHAM   71 HBC  +  K+ P,KO PI+ P     12/75
W      130   (42.)     (12.)               CLARK     73 HBC  -  3.3 K-P,P PI- KO 12/77
W             97.1       3.9               MARTIN    78 SPEC +- 10 K+-P,KS PI P  12/78*
W          . . . . . . . . . .
W   AVG       97.1       3.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W   STUDENT   97.1       4.0     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W   CHARGED ONLY, WITH OTHER FINAL STATES
W    D 130  (105.0)    (37.0)              BADIER    65 HBC  -   3.0 K-P          12/75
W    D 120  (110.)     (40.0)              BASSOMPIE 69 HBC  +   5 K+P (K 2PI)    12/75
W           (43.)      (13.)               FRIEDMAN  69 HBC  -   2.7 K-P (K 2PI)   2/72

W   CHARGED AND NEUTRAL
W      134   (92.0)    (32.0)              FOCARDI   65 HBC  -0 3.0 K- P (K PI) 12/75
W    D  55  (175.)     (94.0)              ADERHOLZ  68 HBC  -0 10 K- P (K PI)  12/75

W   NEUTRAL ONLY
W    D  46   (61.0)    (36.0)              DAHL      67 HBC   0 3.8-4.2 PI- P    12/77
W   SD 160  (116.0)    (37.0)              KANG      68 HBC   0 4.6 K- P         12/75
W  WAD 210  (110.)     (30.0)              BASSOMPIE 69 HBC   0 5 K+P (K PI)     12/75
W     2200   101.       10.                DAVIS     69 HBC   0 12. K+ P (K PI)   9/69
W     1800   116.6      10.3      15.5     AGUILAR1  71 HBC   0 3.9,4.6 K- P     11/71
W    D 600   144.       24.0               CORDS     71 DBC  0 9. K+ N,K+ PI- P 12/75
W    D1100   109.       14.0               BUCHNER   72 DBC  0 4.6 K+ N,K+ PI-P 12/75
W   C        (61.0)    (14.0)              LINGLIN   73 HBC  0 2-13 K+P,K+PI-     1/74
W      800   116.       18.                MCCUBBIN  75 HBC   0 3.6 K-P,K-PI+N   12/75
W    D 300   125.0      29.0               HENDRICKX 76 DBC     8.25 K+N,K+PI     7/77
W  P         170.0      20.0               BOWLER    77 DBC  0 5.5 K+D,K PI P P 12/77
W  P          98.0       5.0               ESTABROOK 78 ASPK 0 13K+-P,P K PI     12/77
W          . . . . . . . . . .
W   AVG      105.8       5.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
W   STUDENT  105.1       4.8     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                (SEE IDEOGRAM BELOW )

W   A   INCLUDED IN LINGLIN 73 WORLD K+P DST
W   C   FROM POLE EXTRAPOLATION, USING WORLD K+P DST
W    D  ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE K* TYPED NOTE.
W  P    FROM PHASE SHIFT ANALYSIS.
W   S   DATA WITH MASS ERROR OF 15 MEV OR MORE NOT AVERAGED
W  W    NUMBER OF EVENTS IN PEAK REEAVALUATED BY US
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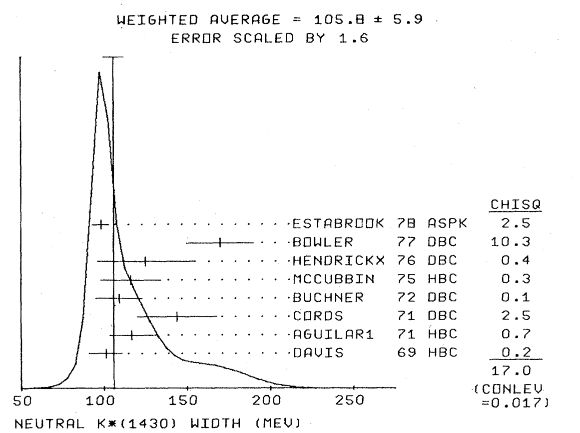


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22  K*(1430) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      K*(1430) INTO K PI                                493+ 139
P2      K*(1430) INTO K*(892) PI                          892+ 139
P3      K*(1430) INTO K RHO                               493+ 776
P4      K*(1430) INTO K OMEGA                             493+ 782
P5      K*(1430) INTO K ETA                               493+ 548
P6      K*(1430) INTO K*(892) PI PI                       892+ 139+ 139
P7      K*(1430) INTO K OMEGA PI                          493+ 782+ 139
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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.4907+-.0163					
P 2	.0641	.2703+-.0215				
P 3	-.0836	-.0010	.0657+-.0145			
P 4	-.1081	-.2010	-.1212	.0369+-.0159		
P 5	-.3209	-.3905	-.2214	-.1600	.0248+-.0261	
P 6	-.2544	-.3690	-.2154	-.1581	-.2722	.1116+-.0248

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22  K*(1430) BRANCHING RATIOS

R1      K*(1430) INTO (K PI)/TOTAL                        (P1)
R1 P          0.49      0.02        ESTABROOK 78 ASPK +- 13K+-P,P K PI    12/77
R1 P     FROM PHASE SHIFTS ANALYSIS.
R1          . . . . . . . . .
R1  FIT       0.491     0.016   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2      K*(1430) INTO (K*(892) PI)/(K PI + K PI PI)       (P2)/(P1+P2+P3)
R2  QR       (.45)     (0.13)       BADIER    65 HBC   -  3.0 K-P           1/78
R2  Q        (0.47)    (0.10)       BASSANO   67 HBC  -0 4.6, 5.0 K- P    10/67

R3      K*(1430) INTO (K RHO)/(K PI + K PI PI)            (P3)/(P1+P2+P3)
R3  QR       (0.14)    (0.07)       BADIER    65 HBC   -  3.0 K-P           1/78
R3  Q        (0.14)    (0.10)       BASSANO   67 HBC  -0 4.6, 5.0 K- P    10/67

R4      K*(1430) INTO (K*(892) PI) / (K PI)               (P2)/(P1)
R4      6     0.33      0.33        CHUNG     65 HBC  + 0  3.9-4.2 PI- P    8/66
R4            0.65      0.20        SHEN      66 HBC    0  N* PRODUCED     10/66
R4  Q        (0.63)    (0.20)       SHEN      66 HBC  +    NO N* PRODUCED 10/66
R4            0.52      0.12        SCHWEINGR 68 HBC    0 4.1+5.5 K- P     10/67
R4  Q        (1.06)    (0.30)       BASSOMPIE 69 HBC   +   5.0 K+P          1/78
R4            0.80      0.30        BASSOMPIE 69 HBC   0   5.0 K+P          1/78
R4  Q   84   (0.93)    (0.11)       BISHOP    69 HBC       3.5 K+ P         9/69
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Mesons
K*(1430), κ(1500)

Data Card Listings
For notation, see key at front of Listings.

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R4              0.47      0.08               AGUILAR1  71 HBC      3.9,4.6 K- P    11/71
R4   G          0.91      0.20               CHARRIERE 73 HBC   0 5. K+ P,K P 3PI   1/73
R4   G  REVISED BY GOLDSCHMIDT 75
R4 AQ  150     (0.65)    (0.25)              ANTIPOV   75 ASPK  - 40 K-P,K*- P    .12/75
R4 A    K* PI SIGNAL FROM PARTIAL WAVE ANALYSIS OF (K-PI+PI-) SYSTEM
R4              0.54      0.16               DEHM      74 DBC   0 4.6 K+ N         12/75
R4              0.62      0.19               LAUSCHER  75 HBC    010,16 K-P,K-PI+N 12/75
R4           . . . . . . . . .
R4   AVG        0.548     0.053   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4   STUDENT    0.544     0.060   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R4   FIT        0.551     0.046  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5     K*(1430) INTO (K OMEGA) / K PI                             (P4)/(P1)
R5   R          0.19      0.16               BADIER    65 HBC   -  3.0 K-P           1/78
R5             (0.08) OR LESS                SHEN      66 HBC      4.6 K+P           8/66
R5             (0.2)  OR LESS                BASSOMPIE 69 HBC   +   5 K+ P           9/69
R5              0.13      0.07               BASSOMPIE 69 HBC    0 5 K+ P            9/69
R5              0.05      0.04               AGUILAR1  71 HBC      3.9-4.6 K- P    11/71
R5             (0.2)  OR LESS  CL=.95        CHUNG     74 HBC   - 7.3 K-P,K*- P    12/75
R5           . . . . . . . . .
R5   AVG        0.075     0.034   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5   STUDENT    0.075     0.038   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R5   FIT        0.075     0.033  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6     K*(1430) INTO (K RHO) / (K PI)                             (P3)/(P1)
R6             (0.09) OR LESS                CHUNG     65 HBC   + 0  3.9-4.2 PI- P   8/66
R6              0.26      0.16               SCHWEINGR 68 HBC    0 4.1+5.5 K- P    10/67
R6             (0.2)  OR LESS                BASSOMPIE 69 HBC   +   5 K+ P           9/69
R6             (0.3)  OR LESS                BASSOMPIE 69 HBC    0 5 K+ P            9/69
R6   Q    15   (0.11)    (0.06)              BISHOP    69 HBC      3.5 K+ P          9/69
R6              0.16      0.05               AGUILAR1  71 HBC      3.9,4.6 K- P    11/71
R6              0.02      0.10      0.02     DEHM      74 DBC   0 4.6 K+ N         12/75
R6   S         (0.24)    (0.14)              LAUSCHER  75 HBC    010,16 K-P,K-PI+N 12/75
R6   S   USES RESULTS OF OTTER 75 (SEE R7 BELOW). WE DO NOT AVERAGE THIS
R6   S   STATISTICALLY REDUNDANT RATIO, BUT KEEP THE LAUSCHER 75 RESULT
R6   S   FOR R4 ABOVE.
R6           . . . . . . . . .
R6   AVG        0.111     0.054   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R6   STUDENT    0.116     0.047   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R6   FIT        0.134     0.030  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R7     K*(1430) INTO (K RHO) / (K*(892) PI)                       (P3)/(P2)
R7             (0.39) OR LESS                BASSOMPIE 67 HBC   +   5. K+ P          9/67
R7             (0.40) OR LESS  CL=.90        FIELD     67 HBC   - 3.8 K- P           6/67
R7 P   130       .13       .09               OTTER     75 HBC    08,10,16 K-P,K* N 12/75
R7 AN          (0.03)    (0.03)              ANTIPOV   75 ASPK  - 40 K-P,K*- P     12/75
R7  N    K RHO MODE NOT OBSERVED
R7 A     FROM PARTIAL WAVE ANALYSIS OF (K-PI+PI-) SYSTEM
R7 P            0.36      0.10               VERGEEST  76 HBC   0 4.2 K-P,P KOPIPI 12/77
R7 P     FROM PARTIAL WAVE ANALYSIS OF (KO PI+ PI-) SYSTEM
R7           . . . . . . . . .
R7   AVG        0.23      0.11    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R7   STUDENT    0.231     0.085   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R7   FIT        0.243     0.057  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R8     K*(1430) INTO (K OMEGA) / (K*(892) PI)                     (P4)/(P2)
R8   Q         (0.10)    (0.04)              FIELD     67 HBC   - 3.8 K- P           6/67

R9     K*(1430) INTO (K ETA) / (K*(892) PI)                       (P5)/(P2)
R9   Q         (0.07)    (0.04)              FIELD     67 HBC   - 3.8 K- P           6/67

R10    K*(1430) INTO (K ETA) / (K PI)                             (P5)/(P1)
R10  R          0.05      0.06               BADIER    65 HBC   -  3.0 K-P           1/78
R10  R         (0.065)OR LESS                BASSOMPIE 69 HBC      5.0 K+P           1/78
R10            (0.02) OR LESS                BISHOP    69 HBC      3.5 K+ P          9/69
R10            (0.04) OR LESS  CL=.95        AGUILAR1  71 HBC      3.9-4.6 K- P    11/71
R10          . . . . . . . . .
R10 FIT         0.050     0.054  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R11    K*(1430) INTO (K*(892) PI PI)/TOTAL                        (P6)
R11T            0.12      0.04               GOLDBERG  76 HBC   -  3 K-P,P KOPIPIPI 12/77
R11          . . . . . . . . .
R11 FIT         0.112     0.025  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R12    K*(1430) INTO (K*(892) PI PI)/(K PI)                       (P6)/(P1)
R12T R          0.21      0.08               JONGEJANS 78 HBC   -  4K-P,P KOOPIPIPI  4/78*
R12          . . . . . . . . .
R12 FIT         0.227     0.053  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R13    K*(1430) INTO (K OMEGA PI)/TOTAL  (UNITS 10**-3) (P7)
R13        0   (0.72) OR LESS  CL=0.95   JONGEJANS 78 HBC      4 K-P,P KO 4PI     4/78*

R    Q   FOLLOWING SUGGESTICN BY AGUILAR 70, WE DO NOT MAKE USE OF MEASURE-
R    Q   MENTS WHERE THE (K PI PI) BACKGROUND SUBTRACTION IS DIFFICULT DUE
R    Q   TO THE NEARBY Q REGION.
R     R  RESTATED BY US.
R   T    ASSUMING PI PI SYSTEM HAS ISO-SPIN 1, WHICH IS SUPPORTED BY
R   T    THE DATA

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REFERENCES FOR K*(1430)


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BADIER    65 PL 19 612          BADIER,DEMOULIN,GOLDBERG+  (EPOL+SACL+AMST)
CHUNG     65 PRL  15  325       +DAHL,HARDY,HESS,JACOBS,KIRZ,MILLER    (LRL)
FOCARDI   65 PL 16 351          FOCARDI,MINGUZZI RANZI,SERRA+(BOLOGNA+SACL)

SHEN      66 PRL  17  726       +BUTTERWORTH,FU,GOLDHABERS,TRILLING    (LRL)
    ALSO 66  (PRIVATE COMMUN)GERSON GOLDHABER                          (LRL)

BASSANO   67 PRL  19  968       +GOLDBERG,GOZ,BARNES,LEITNER+(BNL+SYRACUSE)
BASSOMPI  67 PL 26B 30          BASSOMPIERRE,GOLDSCHMIDT+  (CERN+BRUX+BIRM)IJP
CRENNELL  67 PRL 19  44         +KALBFLEISCH,LAI,SCARR,SCHUMANN        (BNL)
DAHL      67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER                (LRL)
   ALSO   65 PRL 14 401         HARDY,CHUNG,DAHL,HESS,KIRZ,MILLER      (LRL)
DE BAERE  67 NC 51 A 401        +GOLDSCHMIDT-CLERMONT,HENRI+     (BRUX+CERN)
FIELD     67 PL 24B 638         +HENDRICKS+PICCIONI+YAGER          (LAJOLLA)
GOLDHABE  67 PRL 19  972        G.GOLDHABER,FIRESTONE,SHEN             (LRL)

ADERHOLZ  68 NP B 5  567        +DEUTSCHMANN+  (AACH+BERL+CERN+LOIC+VIENNA)
    ALSO  66 PL 22 357          BARTSCH,DEUTSCHMANN,MORRISON+    (ABCL(IC)V)
ANTICH    68 PRL 21 1842       +CALLAHAN,CARSON,COX,DENEGRI,+          (JHU)
DUBAL     68 THESIS   1456      L.DUBAL                             (GENEVE)
KANG      68 PR 176 1587        Y.W.KANG                              (IOWA)
SCHWEING  68 PR 166 1317        SCHWEINGRUBER,DERRICK,FIELDS+    (ANL+NWES)
   ALSO   67  THESIS            F.L.SCHWEINGRUBER   (NORTHWESTERN,EVANSTON)

BASSOMPI  69 NP  B13 189        BASSOMPIERE,GOLDSCHMIDT-CLERM.+ (CERN+BRUX) JP
BISHOP    69 NP B 9 403         +GOSHAW,ERWIN,WALKER                  (WISC)
CRENNELL  69 PRL 22  487        +KARSHON,LAI,ONEALL,SCARR              (BNL)
DAVIS     69 PRL 23 1071        +DERENZO,FLATTE,ALSTON,LYNCH,SOLMITZ   (LRL)
DE BAERE  69 NC 61 A 397        +GOLDSCHMIDT-CLERMONT,HENRI,+    (BELG+CERN)
FRIEDMAN  69  UCRL-18860        J.FRIEDMAN,PH.D. THESIS                (LRL)
LIND      69 NP B 14 1          +ALEXANDER,FIRESTONE,FU,GOLDHABER      (LRL) JP

ABRAMS    70 PR D 1 2433        +EISENSTEIN,KIM,MARSHALL,O.HALLORAN,+ (ILL)
AGUILAR   70 PRL 25 1362        AGUILAR-BENITEZ,BASSANO,EISNER,+ (BNL+PURD)
AGUILAR1  71 PR D 4 2583        +EISNER,KINSON                              (BNL)
BARNHAM   71 NP B 28 171        +COLLEY,JOBES,GRIFFITHS,HUGHES,+(BIRM+GLAS)
CORDS     71 PR D 4 1974        +CARMONY,ERWIN,MEIERE,+        (PURD+UCD+IUPU)

BUCHNER   72 NP B 45 333        +DEHM,CHARRIERE,CORNET,+   (MPIM+CERN+BRUX)
CRENNELL  72 PR D 6 1220        +GORDON,KWAN-WU LAI,SCARR                  (BNL)
DEUTSCHM  72 NP B 36 373        DEUTSCHMANN,+            (ABCLV COLLABORATION)
ENGELMAN  72 PR D 5 2162        ENGELMANN,MUSGRAVE,FORMAN,+            (ANL+EFI)
FRATI     72 PR D 6 2361        +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
ROUGE     72 NP B 46 29         +VIDEAU,VOLTE,DE BRION,+            (EPOL+SACL)
TIECKE    72 NP B 39 596        +GRIJNS,HEINEN,DE GROOT,+           (NIJM+AMST)

CHARRIER  73 NP B 51 317        CHARRIERE,DRIJARD,DE BAERE,+      (CERN+BELG)
    ALSO  75  (PRIVATE COMMUNICATION) GOLDSCHMIDT-CLERMONT              (CERN)
CLARK     73 NP B 54 432        +LYONS,RADOJICIC                        (OXFORD)
DE JONGH  73 NP B 58 110        +CORNET,CHARRIERE,+   (BRUX+MONS+CERN+MPIM)
LINGLIN   73 NP B 55 408        D.LINGLIN                                 (CERN)
WALUCH    73 PR D 8 2837        +FLATTE,FRIEDMAN                           (LBL)

CHUNG     74 PL 51B 413         +EISNER,PROTOPOPESCU,SAMIOS,STRAND         (BNL)
DEHM      74 NP B75 47          +GOEBEL,WITTEK,WOLF,+ (MPIM+BRUX+MONS+CERN)

ANTIPOV   75 NP B86 381         +ASCOLI,BUSNELLO,KIENZLE+     (SERP+CERN+ILL)
LAUSCHER  75 NP B86 189         +OTTER,WIECZOREK,+     (ABCLV COLLABORATION)  JP
MCCUBBIN  75 NP B86 13          N.A.MCCUBBIN,L.LYONS                       (OXF)
OTTER     75 NP B84 333         + (AACH+BERL+CERN+LOIC+VIEN+ATHU+ATEN+LIVP)

ETKIN     76 PRL 36 1482        +FOLEY,GOLDMAN,LINDENBAUM,KIM,+   (BNL+CUNY)
GOLDBERG  76 LNC 17 253         J.GOLDBERG                               (HAIFA)
HENDRICK  76 NP B 112 189       +VIGNAUD,BURLAUD,+      (MONS+SACL+LPNP+BELG)
KIRK      76 NP B 116 99        +KLEIN,COUNIHAN,+(AACH+BERL+CERN+LOIC+WIEN)
VERGEEST  76 PL 62 B 471        +ENGELEN,JONGEJANS,+     (AMST+CERN+NIJM+OXF)  JP

BOWLER    77 NP B 126  31       +DAINTON,DRAKE,WILLIAMS                  (OXFORD)

BALDI     78 NP B 134 365       +BOHRINGER,DORSAZ,HUNGERBUHLER+           (GEVA)
BOHM      78 PRL 41 1761        +VAN DALEN,+ (AACH,UCR+CERN+HARV+MUNC+NWES)
ENGELEN   78 NP B 134 14        +JONGEJANS,HEMINGWAY,+ (NIJM+ZEEM+CERN+OXF)
ESTABROO  78 NP B 133 490       ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)
    ALSO  78 PR D 17 658        ESTABROOKS,CARNEGIE+   (MONT+CARL+DURH+SLAC)
JONGEJAN  78 NP B 139 383       JONGEJANS,CERRADA,+     (ZEEM+CERN+NIJM+OXF)
MARTIN    78 NP B 134 392       +SHIMADA,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)
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κ(1500)

19 KAPPA(1500,JP=0+) I=1/2

S-Wave Kπ Interactions

The Kπ interactions are reminiscent of the ππ interactions, apart from the inelastic thresholds, both for the leading $J^P = 1^-, 2^+, 3^-$ resonances and for the S wave. The first inelastic S-wave thresholds are Kπππ and Kη, neither of these channels being known to be important below 1400 MeV.

From the Kπ threshold to ~1400 MeV, the phase shift δ_0^1 of the $I(J^P) = 1/2(0^+)$ wave is determined uniquely by the requirements of elastic unitarity. It grows monotonically, reaching 40° at about 900 MeV, and 90° at about 1350 MeV, being everywhere well described by an effective range formalism (MERCER 71, BINGHAM 72, FIRESTONE 71,72, MATISON 72,74, GALTIERI 73, YUTA 73, FOX 74, BAKER 75, LAUSCHER 75, BOWLER 77, ESTABROOKS 78); see Fig. 1. The ambiguous "up" solution in the region of the K*(892) has been ruled out conclusively (MATISON 72,74 , GALTIERI 73, BOWLER 77, ESTABROOKS 78).

In the 1400 MeV region the analysis becomes complicated due to the largeness of δ_0^1, to the nearness of the K*(1430) and the resulting strong S-D interference, and to the opening of inelastic channels. Several groups have interpreted the slow passage of δ_0^1 through 90° as evidence for a resonance (FIRESTONE 71,72, FRATI 72, ROUGE 72, CORDS 73, LAUSCHER 75, MORGAN 75, ENGELEN 78), while others contended that δ_0^1 was large but

Data Card Listings

For notation, see key at front of Listings.

non-resonant (AGUILAR 72, BUCHNER 72, CRENNELL 72, ENGELMANN 72, BAKER 75).

New features emerge as the phase-shift analysis is continued up to 1900 MeV on a large-statistics experiment (ESTABROOKS 78). In the inelastic region where the ambiguities cannot be solved ESTABROOKS 78 find four solutions, in all of which the S wave exhibits a rapid drop in the modulus of the amplitude near 1450 MeV; see Fig. 2. This behavior is confirmed with less statistics by BOWLER 77 and MARTIN 78, and a clear circular motion is seen in the Argand plot with a maximum speed in the region 1400-1500 MeV. Thus all four solutions provide evidence for an S-wave 0^+ $K\pi$ resonance. The elasticity is greater than 0.8 in all but one solution. We call this resonance $\kappa(1500)$ and enter it into the Table. ESTABROOKS 79 performs a coupled-channel fit to the mass dependence of the S-wave magnitude and phase using various parametrizations. All the fits result in a second-sheet pole very near the $K\eta'$ threshold with M = 1480-1570 MeV and Γ = 120-400 MeV, depending on which of the four solutions is used as input. No additional pole is required to explain the slow passage of δ_0^1 through 90° at about 1350 MeV. We note that this situation is reminiscent of the $\pi\pi$ system, where the "down" phase shift δ_0^0 goes slowly through 90° at about 850 MeV, far below the $\varepsilon(1300)$ resonance.

The present 0^+ nonet looks rather different from the one considered by MORGAN 75. The ε and κ both have higher masses and smaller widths than before; the ε in addition couples noticeably to $K\bar{K}$.

Finally, we remark that two of the four solutions of ESTABROOKS 78 provide evidence for a second P-wave resonance with mass ~1650 MeV, width ~250 MeV, and elasticity ~0.25. This new state, $K^{*\prime}(1650)$, would, if confirmed, most probably be assigned in the quark model as a radial excitation, similarly to $\rho'(1600)$.

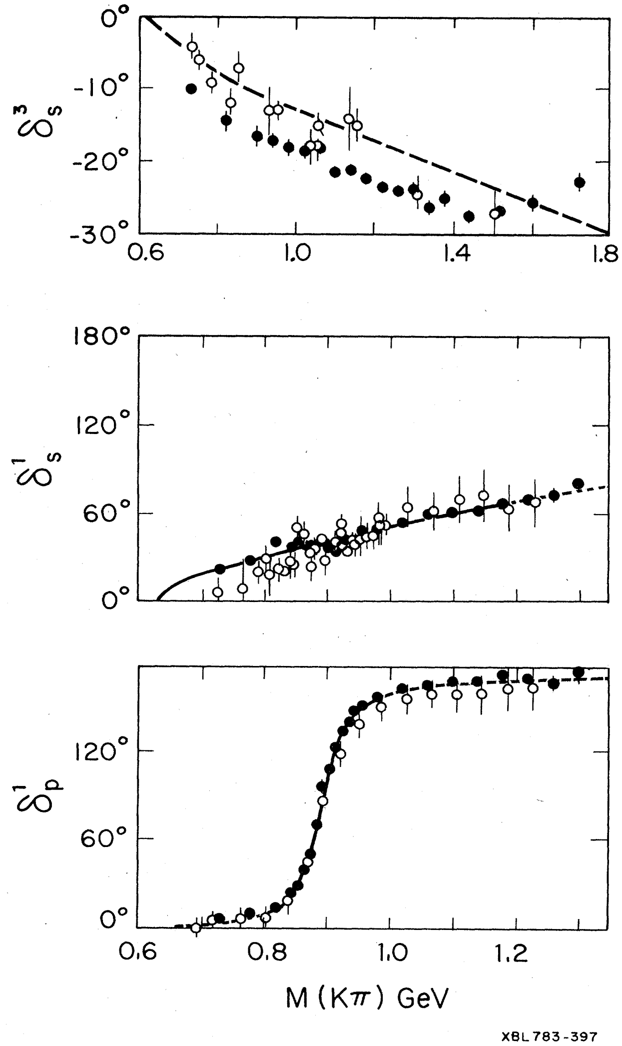

Fig. 1. The solid points are the $K\pi$ phase shifts calculated in a simultaneous analysis of the SLAC 13 GeV/c neutron and Δ recoil reactions. The curves represent the effective range or resonance fits of ESTABROOKS 78, except for the dashed curve on the δ_S^3 plot which represents a constant cross section of 1.8 mb. The open circles are from MERCER 71, BINGHAM 72, BAKER 73, LINGLIN 73, and MATISON 74.

Mesons

κ(1500), L(1580)

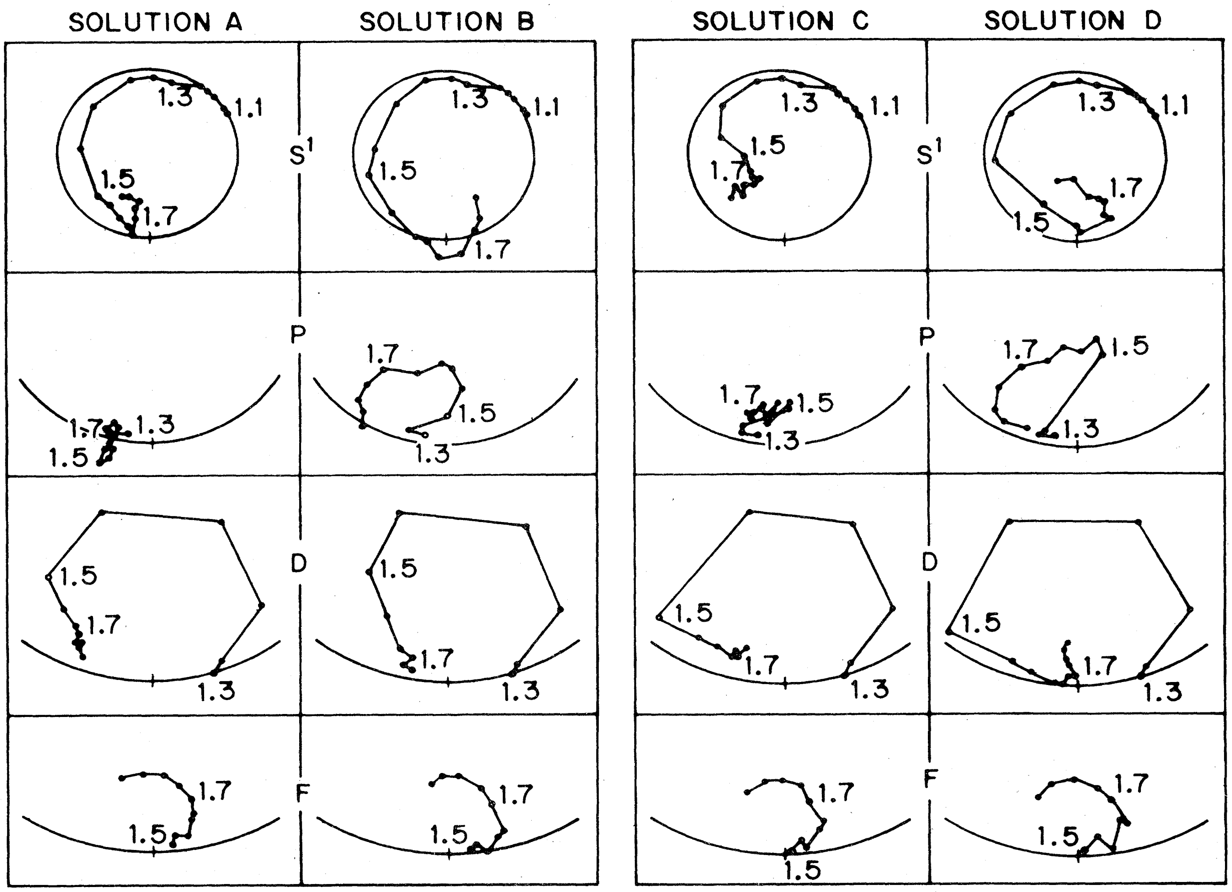

Fig. 2. Argand diagrams for the Kπ partial waves of ESTABROOKS 78.

19 KAPPA MASS (MEV)

M C (1425.) APPROX. ESTABROOK 78 ASPK 13 K+- P 12/77
M (1450.0) APPROX. MARTIN 78 SPEC 10 K+-P,KS PI P 12/78*
M C FROM ELASTIC K PI PARTIAL WAVE ANALYSIS (SEE KAPPA MINI-REVIEW)

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19 KAPPA WIDTH (MEV)

W C 200-300 APPROX. ESTABROOK 78 ASPK 13 K+- P 12/77
W C FROM ELASTIC K PI PARTIAL WAVE ANALYSIS (SEE KAPPA MINI-REVIEW)

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REFERENCES FOR KAPPA

TRIPPE 68 PL 28 B 203 +CHIEN,MALAMUD,MELLEMA,SCHLEIN,+ (UCLA)

CRENNELL 69 PRL 22 487 +KARSHON,LAI,O.NEALL,SCARR (BNL)
DODD 69 PR 177 1994 +JOLDERSMA,PALMER,SAMIOS (BNL)
GOLDBERG 69 PL 30 B 434 SABRE COLLABOR. (SACL+AMST+BGNA+REHO+EPOL)
SCHLEIN 69 ARGONNE CONF. 446 P.SCHLEIN (UCLA)

FIRESTON 71 PRL 26 1460 A.FIRESTONE,G.GOLDHABER,D.LISSAUER (LRL)
MERCER 71 NP B32 381 +ANTICH,CALLAHAN,CHIEN,COX,+ (JOHN HOPKINS)
YUTA 71 PRL 26 1502 +DERRICK,ENGELMANN,MUSGRAVE (ANL+EFI)

AGUILAR 72 PR D 6 11 AGUILAR-BENITEZ,CHUNG,EISNER (BNL)
BINGHAM 72 NP B 41 1 + (INTERNATIONAL K+ COLLABORATION)
BUCHNER 72 NP B 45 333 +DEHM,CHARRIERE,CORNET,+ (MPIM+CERN+BRUX)
CHUNG 72 PRL 29 1570 +EISNER,AGUILAR-BENITEZ (BNL)
CRENNELL 72 PR D 6 1220 +GORDON,KWAN-WU LAI,SCARR (BNL)
DIEBOLD 72 BATAV.CONF. V.3 17R.DIEBOLD RAPPORTEUR TALK (ANL)
ENGELMAN 72 PR D 5 2162 ENGELMANN,MUSGRAVE,FORMAN,+ (ANL+EFI)
FIRESTON 72 PR D 5 2188 +GOLDHABER, LISSAUER, TRILLING (LBL)PWA
FRATI 72 PR D 6 2361 +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
MATISON 72 LBL 1537 (THESIS) REVISED VERSION WILL GO TO PHYS.REV. LBL
ROUGE 72 NP B 46 29 +VIDEAU,VOLTE,DE BRION,+ (EPOL+SACL)

CORDS 73 NP B 54 109 +CARMONY,LANDER,MEIERE,+ (PURD+UCD+IUPU)
GALTIERI 73 LBL 1772 +MATISON,GARNJOST,FLATTE,FRIEDMAN+ (LBL)
LINGLIN 73 NP B 55 408 D.LINGLIN (CERN)
YUTA 73 NP B 52 70 +ENGELMANN,MUSGRAVE,FORMAN,+ (ANL+EFI)

FOX 74 NP B80 403 G.C.FOX,M.L.GRISS (CIT)
MATISON 74 PR D9 1872 +GALTIERI,GARNJOST,FLATTE,FRIEDMAN,+ (LBL)
MORGAN 74 PL 51B 71 D.MORGAN (RHEL)

BAKER 75 NP B99 211 +BANERJEE,CAMPBELL,ALLEN,MARCH+ (LOIC+LOWC)
LAUSCHER 75 NP B86 189 +OTTER,WIECZOREK,+ (ABCLV COLLABORATION)
MORGAN 75 ARGONNE CONF. 45 D.MORGAN (RHEL)

CHIEN 76 NP B 106 355 +FEIOCK,LUCAS,PEVSNER,ZOANIS (BALTIMCRE)

BOWLER 77 NP B 126 31 +DAINTON,DRAKE,WILLIAMS (OXFORD)
SPIRO 77 NP B 125 162 +BARLOUTAUD,COMBER,PALER,+ (SACL+RHEL+EPOL)

BALDI 78 NP B 134 365 +BOHRINGER,DORSAZ,HUNGERBUHLER+ (GEVA)
ENGELEN 78 NP B 134 14 +JONGEJANS,HEMINGWAY,+ (NIJM+ZEEM+CERN+OXF)
ESTABROO 78 NP B 133 490 ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)
MARTIN 78 NP B 134 392 +SHIMADA,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)

ESTABROO 79 PR D 19 2678 P.ESTABROOKS (CARL)
VERGEEST 79 NP B 158 265 +ENGELEN,KITTEL+ (NIJM+AMST+CERN+OXF)

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L(1580) →

39 L(1580,JP=2-) I=1/2

SEEN IN PARTIAL WAVE ANALYSIS OF THE K-PI+PI- SYSTEM
(OTTER 78). SEE L(1770) MINIREVIEW.
NEED CONFIRMATION OMITTED FROM TABLE.

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39 L(1580) MASS (MEV)

M (1580.) APPROX. OTTER 79 - 10,14,16 K- P 12/79*

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39 L(1580) WIDTH (MEV)

W (110.) APPROX. OTTER 79 - 10,14,16 K- P 12/79*

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Data Card Listings

For notation, see key at front of Listings.

Mesons

L(1580), $K^*(1650)$, $K_N(1700)$, L(1770)

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                      39  L(1580) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      L(1580) INTO K*(890) PI                             892+ 139
P2      L(1580) INTO K*(1430) PI                           1434+ 139

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                      39  L(1580) BRANCHING RATIOS

W1      L(1580) INTO K*(890) PI                           (P1)
W1          SEEN                      OTTER     79 HBC  -  10,14,16 K- P     12/79*

W2      L(1580) INTO K*(1430) PI                          (P2)
W2          POSSIBLY SEEN             OTTER     79 HBC  -  10,14,16 K- P     12/79*

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                                  REFERENCES FOR L(1580)

OTTER     79 NP B 147 1          +RUDOLPH,+          (AACH+BERL+CERN+LOIC+WIEN)  JP

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$K^*(1650)$

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29  K*(1650,JP=1-) I=1/2

    SEEN IN K PI PHASE SHIFTS ANALYSIS (ESTRABROOK 78).
    WAIT CONFIRMATION.OMITTED FROM TABLE.

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                      29  K*(1650) MASS (MEV)

M         (1650.)  APPROX.           ESTABROOK 78 ASPK  0 K+-P,K+-PI+-      12/78*

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                      29  K*(1650) WIDTH (MEV)

W          250-300 APPROX.           ESTABROOK 78 ASPK  0 K+-P,K+-PI+-      12/78*

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                                  REFERENCES FOR K*(1650)

ESTABROO 78 NP B 133 490      ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)

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$K_N(1700)$

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27  KN(1700,JP=  ) I = 1/2

    THIS ENTRY CONTAINS VARIOUS PEAKS IN STRANGE MESON
    SYSTEMS REPORTED IN THE 1700 MEV REGION.
    EVIDENCE NOT COMPELLING, OMITTED FROM TABLE.

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                      27  KN(1700) MASS (MEV)

M           (1660.0)                  CARMONY   67 HBC  -  3.8 K-P,OMEGA K 11/67
M   J       (1660.0)    (10.0)        JOBES     67 HBC  +  5. K+ P          12/75
M   J        CLAIMED BY JOBES IN (K PI), (K*(892) PI), AND (K*(1430) PI)
M   J        MODES. K PI BUMP INTERFERES MOSTLY WITH DELTA(1236).
M           (1660.)                   CHARRIERE 73 HBC   0 5. K+ P,K P 3PI   1/73
M         60(1710.)     (15.)         CHUNG     74 HBC  - 7.3K-P,K-OMEGA P 12/75
M    E   137(1692.0)    (6.0)         ETKIN     76 SPEC  06.K-P,K0 PI+PI-    7/77
M    E   NOT SEEN BY JONGEJANS 78 WITH LARGER STATISTICS.

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                      27  KN(1700) WIDTH (MEV)

W   J        (60.0)    (20.0)         JOBES     67 HBC  +  5. K+ P          12/75
W   J     SEE NOTE J ABOVE
W            (60.)                    CHARRIERE 73 HBC   0 5. K+ P,K P 3PI   1/73
W         60 (110.)     (50.)         CHUNG     74 HBC  - 7.3K-P,K-OMEGA P 12/75
W    E   137 (26.0)     (24.0)   (17.0) ETKIN   76 SPEC  06.K-P,K0 PI+PI-    7/77
W    E   NOT SEEN BY JONGEJANS 78 WITH LARGER STATISTICS.

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                      27  KN(1700) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      KN(1700) INTO K PI                                  493+ 139
P2      KN(1700) INTO K PI PI                               493+ 139+ 139
P3      KN(1700) INTO K*(892) PI                            892+ 139
P4      KN(1700) INTO K RHO                                 493+ 776
P5      KN(1700) INTO K*(1430) PI                          1434+ 139
P6      KN(1700) INTO K OMEGA                               493+ 782

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                      27  KN(1700) BRANCHING RATIOS

R1      KN(1700) INTO (K PI)/(K OMEGA)                    (P1)/(P6)
R1 N         (0.5)    (0.5)           CHUNG     74 HBC  - 7.3 K-P,KN- P     12/75
R1 N     NO K PI SIGNAL SEEN IN THIS EXPERIMENT

R2      KN(1700) INTO (K*(892) PI)/(TOTAL K PI PI)        (P3)/(P2)+(P3)
R2           (0.5)                    ETKIN     76 SPEC  06.K-P,K0 PI+PI-    7/77

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                                  REFERENCES FOR KN(1700)

CARMONY  67 PRL  18  615        D.CARMONY,T.HENDRICKS,L.LANDER   (LA JOLLA)
JOBES    67 PL 26B 49           +BASSOMPIERRE,DE BAERE +   (BIRM+CERN+BRUX)
CHARRIER 73 NP B 51 317         CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)
CHUNG    74 PL 51B 412          +EISNER,PROTOPOPESCU,SAMIOS,STRAND     (BNL)
ETKIN    76 PRL 36 1482         +FOLEY,GOLDMAN,LINDENBAUM,KIM,+  (BNL+CUNY)
JONGEJAN 78 NP B 139 383        JONGEJANS,CERRADA,+     (ZEEM+CERN+NIJM+OXF)

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L(1770)

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23  L(1770, JP=  ) I = 1/2
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The L(1770) is seen as a bump in the diffractive-like process $KN \to (K\pi\pi)N$. BARBARO 69 and FIRESTONE 72 find the decay is consistent with being entirely $K^*(1430)\pi$, whereas AGUILAR 70, BARTSCH 70, COLLEY 71, and DENEGRI 71 present evidence for alternate decay modes. For a review see EISNER 74.

Partial-wave analyses (DEUTSCHMANN 74, ANTIPOV 75, OTTER 75,79) have shown that the situation in the L region is complicated with many unnatural parity waves contributing. The 2^- $K^*(1430)\pi$ S wave is important, but cannot explain the whole L enhancement.

On the other hand, OTTER 79 propose the existence of a 2^- resonance of mass $\approx$1580 MeV and width $\approx$110 MeV to explain the sharp rise of the 2^- $K^*(1430)\pi$ channel, the peak in the 2^- $K^*(892)\pi$ partial wave, and the observed phase variation. Further confirmation is, however, needed before considering this an established resonance.

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                      23  L(1770) MASS  (MEV)

M        20(1780.)                        BERLINGHI 67 HBC  +   12.7 K+P          7/67
M          (1760.0)    (15.0)             JOBES     67 HBC  +   5. K+ P           1/73
M           1745.0      20.0              AGUILAR   70 HBC   -  4.6 K- P          6/70
M           1780.0      15.0              BARTSCH   70 HBC   -  10.1 K- P         1/71
M          (1760.0)    (15.0)             LUDLAM    70 HBC   -  12.6 K- P         1/73
M   X       1765.0      40.0              COLLEY    71 HBC  +  10.K+P,K 2PI       1/73
M   X    SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
M          (1740.0)                       DENEGRI   71 DBC   - 12.6 K-D,K 2PI D  5/71
M           1767.       6.                BLIEDEN   72 MMS  -  11.-16. K- P     12/72
M   P   306 1730.       20.               FIRESTONE 72 DBC  +  12. K+ D           1/73
M   P    PRODUCED IN CONJUNCTION WITH D*
M           . . . . . . . . .
M   AVG     1764.6      6.7      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
M   STUDENT1765.0       5.8      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                      23  L(1770) WIDTH (MEV)

W        20  (80.)                        BERLINGHI 67 HBC  +   12.7 K+P          7/67
W            (60.0)    (20.0)             JOBES     67 HBC  +   5. K+ P           1/73
W            100.0      50.0              AGUILAR   70 HBC   -  4.6 K- P          6/70
W            138.0      40.0              BARTSCH   70 HBC   -  10.1 K- P         1/71
W            (50.0)    (40.0)   (20.0)    LUDLAM    70 HBC   -  12.6 K- P         1/73
W   X         90.       70.               COLLEY    71 HBC  +  10.K+P,K 2PI       1/73
W   X    SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
W           (130.0)                       DENEGRI   71 DBC   - 12.6 K-D,K 2PI D  5/71
W            100.       26.               BLIEDEN   72 MMS  -  11.-16. K- P     12/72
W   P   306  210.       30.               FIRESTONE 72 DBC  +  12. K+ D          12/72
W   P    PRODUCED IN CONJUNCTION WITH D*
W           . . . . . . . . .
W   AVG      137.7      24.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
W   STUDENT 130.7       21.5     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                      23  L(1770) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1      L INTO K PI PI                                           497+ 134+ 134
P2      L INTO K*(1430) PI                                       134+1434
P3      L INTO K PI PI PI                                        497+ 134+ 134+ 134
P4      L INTO K*(892) PI                                        892+ 134
P5      L INTO K*(892) RHO                                       892+ 776
P6      L INTO K*(892) OMEGA                                     892+ 782
P7      L INTO K*(892) PI PI                                     892+ 134+ 134

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                      23  L(1770) BRANCHING RATIOS

R1      L INTO (K*(1430) PI) / (K PI PI )                    (P2)/(P1)
R1          LARGE                         DENEGRI   68 DBC   -  12.6 K- D         1/71
R1           (1.0)                        BARBARO   69 HBC  +   12.0 K+ P         1/71
R1            0.2       0.2               AGUILAR   70 HBC   -  4.6 K- P          1/71
R1          LESS THAN   1.0               BARTSCH   70 HBC   -  10.1 K- P         1/71
R1          LESS THAN   1.0               COLLEY    71 HBC      10. K+ P         11/71
R1   P      CONSISTENT WITH 1.            FIRESTONE 72 DBC  +   12. K+ D         12/72
R1   P   PRODUCED IN CONJUNCTION WITH D*
R1    R  LESS THAN 1.0 SEEMS TO BE ESTABLISHED.
R1    R  FOR DISCUSSION OF THE EXPERIMENTAL EVIDENCE ON OTHER DECAY
R1    R  MODES SEE HUGHES 71,SLATTERY 71,EISNER 74.

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Mesons

L(1770), K*(1780)

Data Card Listings

For notation, see key at front of Listings.


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                              REFERENCES FOR L(1770)

BARTSCH  66 PL 22 357         +DEUTSCHMANN,+    (AACH+BERL+CERN+LOIC+VIEN)

BERLINGH 67 PRL 18 1087       BERLINGHIERI+FARBER+FERBEL+FORMAN+    (ROCH)I
JOBES    67 PL 26B 49         +BASSOMPIERRE,DE BAERE +   (BIRM+CERN+BRUX)

BARTSCH  68 NP B8 9           +COCCONI,+        (AACH+BERL+CERN+LOIC+VIEN)
DENEGRI  68 PRL 20 1194       +CALLAHAN+ETTLINGER+GILLESPIE+          (JHU)

ANDREWS  69 PRL 22 731        +LACH,LUDLAM,SANDWEISS,BERGER,+  (YALE+LRL)
BARBARO  69 PRL 22 1207       BARBARO-GALTIERI,DAVIS,FLATTE,+         (LRL)
COLLEY   69 NC A 59 519       +EASTWOOD,+  (BIRM+GLAS+LOIC+MPIM+OXF+RHEL)

AGUILAR  70 PRL 25 54         AGUILAR-BENITEZ,BARNES,BASSANO,CHUNG,+(BNL)
BARTSCH  70 PL 33 B 186       +DEUTSCHMANN,+    (AACH+BERL+CERN+LOIC+VIEN)
LUDLAM   70 PR D 2 1234       +SANDWEISS,SLAUGHTER                   (YALE)

COLLEY   71 NP B 26 71        +JOBES,KENYON,PATHAK,HUGHES,+   (BIRM+GLAS)
DENEGRI  71 NP B 28 13        +ANTICH,CALLAHAN,CARSON,CHIEN,COX,+   (JHU)  JP

ANDERSON 72 PR D 6 1823       +FRANKLIN,GODDEN,KOPELMAN,LIBBY,TAN  (COLO)
BLIEDEN  72 PL 39 B 668       +FINOCCHIARO,BOWEN,EARLES,+     (STON+NEAS)
FIRESTON 72 PR D 5 505        FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)

BARLOUTA 73 NP B 59 374       +DREVILLCN,SHAH,+              (SACL+EPOL+RHEL)
BINGHAM  73 NP B 52 31        +FARWEL,+        (LBL+ORSAY+BNL+SACLAY+MILAN)
CHARRIER 73 NP B 51 317       CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)

DEUTSCHM 74 PL 49B 388        DEUTSCHMANN,+     (AACH+BERL+CERN+LOIC+VIEN)  JP
EISNER   74 BOSTON CONF.      R.L.EISNER  REVIEW TALK                 (BNL)

ANTIPOV  75 NP B86 381        +ASCOLI,BUSNELLO,KIENZLE+   (SERP+CERN+ILL)  JP
OTTER    75 NP B93 365        +RUDOLPH,RUMPF+   (AACH+BERL+CERN+LOIC+VIEN)  JP
    ALSO 77  PREP. AACHEN 41            /AACHEN+BERLIN+CERN+LOIC+VIENNA   JP

OTTER    79 NP B 147 1        +RUDOLPH,+        (AACH+BERL+CERN+LOIC+WIEN)  JP

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K*(1780)

60 K*(1780,JP=3-)

Evidence for K*(1780) has been reported by a number of experiments which observe peaks of low statistical significance around 1800 MeV in the mass spectra of Kπ and Kππ systems produced both with charge exchange (CARMONY 71, AGUILAR 73, SPIRO 76. CARMONY 77, GRASSLER 77) and without charge exchange (SPIRO 76). The large variation in the measured values of the mass (see the Data Card Listings) leads GRASSLER 77 to suggest that there may be further structure at higher mass (around 1850 MeV).

Additional evidence for the K*(1780) has come from observations of structure in the charge-exchange Kπ angular distribution at ~1800 MeV (FIRESTONE 71, BRANDENBURG 76), which can be explained by a rapid rise of the F-wave amplitude interfering strongly with other waves. This behavior has been interpreted by BRANDENBURG 76 as implying the existence of a resonance with $J^P = 3^-$, $M \sim 1780$ MeV, and $\Gamma \sim 270$ MeV. The existence of such a resonance has been confirmed by BALDI 76 and CHUNG 78. BALDI 76 analyze non-charge-exchange data and find significant signals at ~1780 MeV in all moments up to $L = 6$. A clear, statistically significant peak at ~1786 MeV is observed by CHUNG 78 in their charge-exchange Kπ mass spectrum. Both of these experiments obtain narrower widths than BRANDENBURG 76. BALDI 76 finds a width of 135 ± 22 MeV and CHUNG 78 a width of 95 ± 31 MeV.

There have been two phase-shift analyses of the Kπ system in this energy region. The energy-dependent analysis of BOWLER 77 supports the existence of a broad $J^P = 3^-$ resonance at ~1760 MeV with a width ~300 MeV. The problem of the width has been partly resolved by the ESTABROOKS 78 analysis of the high-statistics spectrometer data of BRANDENBURG 76. ESTABROOKS 78 find four solutions (see the Kπ S-wave mini-review), all of which are compatible with the existence of an F-wave resonance at ~1780 MeV with a width ~175 MeV and elasticity ~0.2. The Kππ decay mode has been confirmed by BEUSCH 78 with good statistics and can be considered established.

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                    60  K*(1780) MASS (MEV)

M   C   76(1753.)     (12.)              CARMONY   71 DBC    09 K+N,K+PI-P      11/71
M   C  PRESENCE OF RESONANCE ONLY INDICATED BY HOLE AT 1600 MEV,FIT
M   C  DFFICULT.SEE ALSO CARMONY 77.
M   I     (1850.)   APPROX.              FIRESTONE 71 DBC    0 12.K+ N,K+ PI-P 11/71
M   I       APPARENT INTERFERENCE WITH OTHER AMPLITUDES PRECLUDES
M   I       PRECISE DETERMINATION .
M       65(1760.)                        AGUILAR   73 HBC    07.3 K-P,K-PI+N     1/74
M    M      1779.0      11.0             BALDI     76 SPEC +  10 K+P,K0 PI+P   12/77
M    M  FROM A FIT TO Y(6,2) MOMENT. JP=3- FOUND.
M    A      1776.       26.              BRANDENB  76 ASPK   013 K+-P,K+-PI-+  12/75
M    A  CCNFIRMED BY PHASE SHIFT ANALYSIS OF ESTABROOKS 77,YIELDS JP=3-
M       40(1780.)     (30.)              SPIRO     76 HBC   - 14.3 K-P,K0PI-P  12/75
M   G   80(1840.)     (30.)              SPIRO     76 HBC    014.3 K-P,K-PI+N  12/75
M    B    (1760.0)  APPROX.              BOWLER    77 DBC   0 5.4 K+D,K+PI-P P 12/77
M    B  PHASE SHIFT ANALYSIS,YIELDS JP=3-.
M      127 1789.0      18.0              CARMONY   77 DBC   0 9 K+N,K0 PI+PI-P 12/77
M   G     (1871.0)    (10.0)             GRASSLER  77 HBC   0 10-16 K-P,K-PI+N 12/77
M           1812.0      28.0             BEUSCH    78 OMEG    10K-P,K0 PI+PI-N  4/78*
M           1786.0       8.0             CHUNG     78 MPS   0 K-P,K-PI+N 6 GEV  1/78
M           . . . . . . . . .
M   AVG     1785.0       5.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1784.9        6.3      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M   G     GRASSLER 77 PROPOSE THE EXISTENCE OF ANOTHER OBJECT.
M   G     NOT AVERAGED
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                    60  K*(1780) WIDTH (MEV)

W   C   76  (60.)     (20.)              CARMONY   71 DBC    09 K+N,K+PI-P      11/71
W   C   SEE NOTE C ABOVE
W   I     (300.)    APPROX.              FIRESTONE 71 DBC    0 12.K+ N,K+ PI-P 11/71
W   I   SEE NOTE I ABOVE
W       65  (80.)    OR LESS             AGUILAR   73 HBC    07.3 K-P,K-PI+N     1/74
W    M      135.0       22.0             BALDI     76 SPEC +  10 K+P,K0 PI+P   12/77
W    M  FROM A FIT TO Y(6,2) MOMENT. JP=3- FOUND.
W   E     (270.)      (70.)              BRANDENB  76 ASPK   013 K+-P,K+-PI-+  12/75
W   E     ESTABROOKS 77 FIND THAT BRANDENBURG 76 DATA ARE CONSISTENT
W   E     WITH 175 MEV WIDTH.NOT AVERAGED.
W   D   40 (120.)     (75.)              SPIRO     76 HBC   - 14.3 K-P,K0PI-P  12/77
W  GD   80 (100.)     (45.)              SPIRO     76 HBC    014.3 K-P,K-PI+N  12/77
W    B    (300.0)   APPROX.              BOWLER    77 DBC   0 5.4 K+D,K+PI-P P 12/77
W    B SEE NOTE ABOVE
W      127   85.0       50.0             CARMCNY   77 DBC   0 9 K+N,K0 PI+PI-P 12/77
W  G      (285.0)    (40.0)              GRASSLER  77 HBC   0 10-16 K-P,K-PI+N 12/77
W  D        181.0       44.0             BEUSCH    78 OMEG    10K-P,K0 PI+PI-N  4/78*
W            96.0       31.0             CHUNG     78 MPS   0 K-P,K-PI+N 6 GEV  1/78
W           . . . . . . . . .
W   AVG      125.8      16.6      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
W   STUDENT 125.7       18.0      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W    D  ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE K* TYPED NOTE.
W  G    SEE NOTE ABOVE.

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                    60  K*(1780) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      K*(1780) INTO K PI                               493+ 139
P2      K*(1780) INTO K*(892) PI                         892+ 139
P3      K*(1780) INTO K RHO                              493+ 776
P4      K*(1780) INTO K*(1430) PI                       1434+ 139
P5      K*(1780) INTO K PI PI                            493+ 139+ 139
P6      K*(1780) INTO K*(890) RHO                       1100+ 776

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                    60  K*(1780) BRANCHING RATIOS

R1      K*(1780) INTO (K*(892) PI + K RHO)/(K PI)         (P2+P3)/P1
R1             0.9         0.4           AGUILAR   73 HBC     7.3 K-P,K-PI+N   12/77
R1             0.4         0.6           SPIRO     76 HBC     14.3 P-P,K0-PI+- 12/77
R1             1.59        0.44          CARMCNY   77 DBC   0 9 K+N,K0 PI+PI-P 12/77
R1          . . . . . . . . .
R1  AVG        1.05        0.32     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R1  STUDENT    1.04        0.31     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R2      K*(178C) INTO (K*(892) PI)/(K PI PI)              (P2)/(P5)
R2             0.33        0.12          CARMONY   77 DBC    0 9. K+ N          12/77

R3      K*(1780) INTO (K RHO)/(K PI PI)                   (P3)/(P5)
R3             0.48        0.14          CARMONY   77 DBC    0 9. K+ N          12/77
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Data Card Listings

Mesons

For notation, see key at front of Listings. K*(1780), K*(2200), I(2600), D±, D0, D*±, D*0

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R4     K*(1780) INTO (K PI )/TOTAL                      (P1)
R4   B     (0.3)  OR LESS               BOWLER     77 DBC   0 5.4 K+D,K+PI-P P 12/77
R4   B      0.19      0.02              ESTABROO  78 ASPK  0 13 K+-P,K PI      12/77
R4   B  SEE NOTE ABOVE.

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                          REFERENCES FOR K*(1780)

CARMONY   71 PRL 27 1160       +CORDS,CLOPP,ERWIN,MEIERE,+  (PURD+UCD+IUPU)
FIRESTON 71 PL 36 B 513        FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)
AGUILAR   73 PRL 30 672        +CHUNG,EISNER,PROTOPOPESCU,SAMIOS,+    (BNL)
WALUCH    73 PR D 8 2837       +FLATTE,FRIEDMAN                       (LBL)

BALDI     76 PL 63 B 344       +BOEHRINGER,DORSAZ,HUNGERBUHLER,+  (GENEVA)  JP
BRANDENB 76 PL 60 B 478        BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)  JP
SPIRO     76 PL 60 B 389       +BARLOUTAUD,PALER,CHAURAND+(SACL+RHEL+EPOL)  JP

BOWLER    77 NP B 126 31       +DAINTON,DRAKE,WILLIAMS            (OXFORD)  JP
CARMONY   77 PRD 16 1251       +CLOPP,LANDER,MEIERE,YEN,+   (PURD+UCD+IUPU)
GRASSLER 77 NP B 125 189       +KLUGOW,+   (AACHEN+BERLIN+CERN+LOIC+VIENNA)

BEUSCH    78 PL 74 B 282       +BIRMAN,KONIGS,OTTER,+        (CERN+AACH+ETH)  JP
CHUNG     78 PRL 40 355        +ETKIN,FLAMINO+    (BNL+BRAN+CUNY+MASA+PENN)  JP
ESTABROO 78 NP B 133 490       ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)  JP
   ALSO  78 PR D 17 658        ESTABROOKS,CARNEGIE+  (MONT+CARL+DURH+SLAC)

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K*(2200)

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 40  K*(2200,JP=  )

     THIS ENTRY CONTAINS VARIOUS PEAKS IN STRANGE MESON
     SYSTEMS REPORTED IN THE 2100-2200 MEV REGION AS WELL AS
     ENHANCEMENTS SEEN IN ANTIHYPERON NUCLEON MASS
     SPECTRA. A MOMENTS ANALYSIS OF THE CLELAND 80 DATA
     GIVES EVIDENCE FOR TWO RESONANCES AT 2.3 AND 2.5 GEV
     WITH JP=2- AND 4- COUPLING TO ANTI-LAMBDA P (WITH 50
GEV/C INCIDENT K+) AND LAMBDA ANTI-PROTON (WITH 50 GEV/C INCIDENT K-).
INTERPRETATION UNCERTAIN. OMITTED FROM TTHE TABLE.

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                      40  K*(2200) MASS (MEV)

M        20(2240.)    (20.)          LISSAUER  70 HBC     9. K+ P        11/71
M   C      (2200.)   APPROX.         SLATTERY  71 RVUE    8-13 K+ P      11/71
M   C   COMPILATION OF (ANTIHYP.-NUCLEON) MASS IN K+ P 8.-13.  GEV/C
M   P   488(2115.)    (46.)          CARMONY   77 HBC   0 9 K+D,K+ PIONS  12/78*
M   P   JP=4+ PREFERRED FROM MOMENTS ANALYSIS.
M        37(2147.)    (4.)           CHLIAPNIK 79 HBC  +  K+P TO LAM-BAR P  1/80*
M     Q    (2320.)   APPROX.         CLELAND   80 SPEC +- LAMBDA ANTI-P+CC  1/80*
M     Q  JP=2- FROM MOMENTS ANALYSIS.
M     R    (2510.)   APPROX.         CLELAND   80 SPEC +- LAMBDA ANTI-P+CC  1/80*
M     R  JP=4- FROM MOMENTS ANALYSIS.

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                      40  K*(2200) WIDTH (MEV)

W        20  (80.)    (20.)          LISSAUER  70 HBC     9. K+ P        11/71
W   C      (200.)    APPROX.         SLATTERY  71 RVUE    8-13 K+ P      11/71
W   C   COMPILATION OF (ANTIHYP.-NUCLEON) MASS IN K+ P 8.-13.  GEV/C
W   P      (300.)    (200.)          CARMONY   77 HBC   0 9 K+D,K+ PIONS  12/78*
W   P   JP=4+ PREFERRED FROM MOMENTS ANALYSIS.
W        37  (40.)   APPROX.         CHLIAPNIK 79 HBC  +  K+P TO LAM-BAR P  1/80*
W     Q    (250.)    APPROX.         CLELAND   80 SPEC +- LAMBDA ANTI-P+CC  1/80*
W     Q  JP=2- FROM MOMENTS ANALYSIS.
W     R    (250.)    APPROX.         CLELAND   80 SPEC +- LAMBDA ANTI-P+CC  1/80*
W     R  JP=4- FROM MOMENTS ANALYSIS.

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                          REFERENCES FOR K*(2200)

ALEXANDE 68 PRL 20 755         ALEXANDER,FIRESTONE,GOLDHABER,SHEN     (LRL)
LISSAUER 70 NP B 18 491        +ALEXANDER,FIRESTONE,GOLDHABER         (LBL)

CARMONY   71 PRL 27 1160       +CORDS,CLOPP,ERWIN,MEIERE,+  (PURD+UCD+IND)
SLATTERY 71  UR-875-332(PREP)  P.SLATTERY,A REVIEW OF STRANGE MESONS(ROCH)

CARMONY   77 PRD 16 1251       +CLOPP,LANDER,MEIERE,YEN,+   (PURD+UCD+IUPU)
CHLIAPNI 79 NP B 158 253       CHLIAPNIKOV,GERDYUKOV+       (CERN+BELG+MONS)
CLELAND   80 PL B 89 290       +DELFOSSE,DORSAZ+(PITT,GEVA,LAUS,CERN,DURH)  JP

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I(2600)

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 24  I(2600)

     THIS ENTRY CONTAINS HIGH-MASS, NARROW STRANGE PEAKS.
     OMITTED FROM TABLE.

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                        24  I MASS (MEV)

M  N   130 2600.0      10.0            APOSTOLAK 77 HBC  +- 12PB P,KSPIPIPI  12/77
M  N    NOT SEEN BY APELDOORN 78 IN THE SAME REACTION AND
M  N    WITH ABOUT THE SAME STATISTICS, BUT POORER RESOLUTION.
M  N    THE DISAGREEMENT IS AT A LEVEL OF ABOUT 2 STD.DEV.
M  N    ALSO NOT SEEN BY WHITMORE 78.
M

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                        24  I WIDTH (MEV)

W  N   130  (10.0)  OR LESS          APOSTOLAK 77 HBC  +- 12PB P,KSPIPIPI  12/77
W  N    SEE NOTE N ABOVE.

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                          REFERENCES FOR I

APOSTOLA 77 PL 66 B 185        APOSTOLAKIS,+      (CERN+MONS+LOIC+BELG+LALO)
APELDOOR 78 PL 72 B 487        APELDOORN,KARIMAKI,+  (AMST+HELS+LIVP+STOH)
WHITMORE 78 PL 76 B 649        +LACH,KITAGAKI,CANTER,+(MSU+FNAL+TOHO+TUFT)

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C=±1 MESON STATES

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D±

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 31  CHARGED D(1868,JP=0-) I=1/2

     SEE STABLE PARTICLE DATA CARD LISTINGS

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D0

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 32  NEUTRAL D(1863,JP=0-) I=1/2

     SEE STABLE PARTICLE DATA CARD LISTINGS

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D*±(2010)

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 62  CHARGED D*(2010,JP=1-) I=1/2

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                   62  CHARGED D*(2010) MASS (MEV)

M    G      (2008.)     (3.)          GOLDHAB2  77 SMAG +- E+E-              12/77
M     P      2008.6      1.0          PERUZZI   77 SMAG +- E+E-              12/77

M    G    FROM SIMULTANEUS FIT TO D*+,D*0,D+,AND D0,NOT INDEPENDENT OF
M    G    FELDMAN 77 MASS DIFFERENCE BELOW.
M     P   PERUZZI 77 MASS NOT INDEPENDENT OF FELDMAN 77 MASS DIFFERENCE
M     P   BELOW AND PERUZZI 77 D0 MASS VALUE.

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                   62  (D*+) - (D0) MASS DIFFERENCE (MEV)

DM        30  145.3       0.5         FELDMAN   77 SMAG      D*+ TO D0 PI+    12/77
DM         2  145.2       0.6         BLIETSCHA 79 BEBC      NEUTRINO P      12/79*
DM            . . . . . . . . .
DM   AVG      145.26      0.38   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
DM   STUDENT  145.26      0.41   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                   62  (D*+) - (D*0) MASS DIFFERENCE (MEV)

EM   P        2.6         1.8         PERUZZI   77 SMAG +- E+E-              12/77
EM   P   NOT INDEPENDENT OF FELDMAN 77 MASS DIFFERENCE ABOVE, PERUZZI 77
EM   P   D0 MASS, AND GOLDHABER2 77 D*0 MASS.

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                   62  CHARGED D*(2010) WIDTH (MEV)

W        18   (20.0)  OR LESS         PERUZZI   76 SMAG +- E+E-,PSI(4030)    1/77
W        30   (2.0)   OR LESS  CL=.90 FELDMAN   77 SMAG    D*+ TO D0 PI+    12/77

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                   62  CHARGED D*(2010) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      D*+(2010) INTO D0 PI+                            1863+ 139
P2      D*+(2010) INTO D+ GAMMA                          1868+   0
P3      D*+(2010) INTO D+ PI0                            1868+ 134

P       D*-(2010) MODES ARE CHARGE CONJUGATES OF ABOVE MODES

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                   62  CHARGED D*(2010) BRANCHING RATIOS

R1      D*+(2010) INTO (D0 PI+)/TOTAL                    (P1)
R1 G          0.6         0.15        GOLDHAB2  77 SMAG +  E+E-              12/77
R1 G      ASSUMING THAT ISOSPIN IS CONSERVED IN THE DECAY

R2      D*+(2010) INTO (D+ GAMMA)/TOTAL                  (P2)
R2            0.08        0.07        KIRKBY    79 RVUE    E+ E-            12/79*

R3      D*+(2010) INTO (D+ PI0)/TOTAL                    (P3)
R3    G       0.28        0.09        KIRKBY    79 RVUE    E+ E-            12/79*

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                      REFERENCES FOR CHARGED D*(2010)

PERUZZI   76 PRL 37 569        +PICCOLO,FELDMAN,NGUYEN,WISS,+    (SLAC+LBL)

FELDMAN   77 PRL 38 1313       +PERUZZI,PICCOLO,ABRAMS,ALAM+     (SLAC+LBL)
PERUZZI   77 PRL 39 1301       +PICCOLO,FELDMAN,PERL,+(SLAC,LBL,NWES+HAWA)
GOLDHAB1 77 CHICAGO APS        G.GOLDHABER                       (LBL+SLAC)
GOLDHAB2 77 PL 69 B 503        +WISS,ABRAMS,ALAM,BOYARSKI,+      (LBL+SLAC)

BLIETSCH 79 PL 86 B 108        BLIETSCHAU,+          (AACH+BONN+CERN+MPIM+OXF)
KIRKBY    79  SLAC-PUB 2419    J. KIRKBY                             (SLAC)

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D*0(2010)

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 61  NEUTRAL D*(2010,JP=1-) I=1/2

     J CONSISTENT WITH 1, VALUE 0 RULED OUT (NGUYEN 77).

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                   61  NEUTRAL D*(2010) MASS (MEV)

M  G        2006.        1.5          GOLDHABE  77 SMAG    E+E-              12/77
M  G    FROM SIMULTANEUS FIT TO D*+,D*0,D+,AND D0.

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                   61  NEUTRAL D*(2010) WIDTH (MEV)

W              (5.)    OR LESS        GOLDHAB2  76 SMAG    E+E- TO D*D*      3/77

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Mesons

$D^{*0}(2010)$, $F^{\pm}$, $F^{*}(2140)$, EXOTICS

Data Card Listings

For notation, see key at front of Listings.

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                    61  NEUTRAL D*(2010) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      D*0(2010) INTO D0 PI0                                1863+ 134
P2      D*0(2010) INTO D0 GAMMA                              1863+   0

P       D*0(2010)BAR MODES ARE CHARGE CONJUGATES OF ABOVE MODES

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                    61  NEUTRAL D*(2010) BRANCHING RATIOS

R1      D*0(2010) INTO (D0 GAMMA)/(D0 PI0 + D0 GAMMA)       (P2)/(P1+P2)
R1   G        0.45      0.15          GOLDHABE  77 SMAG    E+E-            12/77
R1   G  WE QUOTE THE NORMAL FIT VALUE FROM TABLE 1. THE ISO-SPIN
R1   G  CONSTRAINED FIT IS NOW KNOWN TO GIVE A D0 GAMMA FRACTION WHICH IS
R1   G  TOO LARGE. SEE DETAILS IN FOOTNOTE 21 OF FELDMAN 77 REVIEW.

R2      D*0(2010) INTO (D0 PI0)/TOTAL                       (P1)
R2    G        0.55      0.15          KIRKBY    79 RVUE    E+ E-           12/79*

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                         REFERENCES FOR NEUTRAL D*(2010)

GOLDHAB1 76 PRL 37 255         GOLDHABER,PIERRE,ABRAMS,ALAM,+    (LBL+SLAC)
GOLDHAB2 76 SLAC CONF. 379     G.GOLDHABER (AVAIL. AS LBL-5534) (LBL+SLAC)

GOLDHABE 77 PL 69 B 503        GOLDHABER,ABRAMS,ALAM+            (LBL+SLAC)
NGUYEN   77 PRL 39 262         +WISS,ABRAMS,ALAM,BOYARSKI,+      (LBL+SLAC)  J

KIRKBY   79  SLAC-PUB 2419     J. KIRKBY                             (SLAC)

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F±

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                    34  F+-(2030,JP=   ) I=

                    SEE STABLE PARTICLE DATA CARD LISTINGS

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F*(2140)

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                    74  F*(2140,JPG=     ) I=

                    OMITTED FROM TABLE.

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                    74  F* MASS (MEV)

M          2140.0     60.          BRANDELIK 77 DASP +- E+E-,PI 3 GAMMA  12/77

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                    74  (F*+) - (F0) MASS DIFFERENCE (MEV)

DM          110.       46.         BRANDELIK 79 DASP +- E+E-,F GAMMA     12/79*

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                    74  F* PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      F* INTO F GAMMA                                      2030+   0

------ --------- --------- --------- --------- --------- --------- --------

                    74  F* BRANCHING RATIOS

R1      F* INTO (F GAMMA)/TOTAL                             (P1)
R1        PROBABLY SEEN                BRANDELIK 77 DASP    E+E-            12/77

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                         REFERENCES FOR F*(2140)

BRANDELI 77 PL 70 B 132        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
BRANDELI 78 PL 76 B 361        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
BRANDELI 79 PL 80 B 412        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)

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EXOTIC MESON STATES

EXOTICS

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                    50  EXOTICS

                    THE PURPOSE OF THIS ENTRY IS TO PROVIDE A LIST OF
                    REFERENCES FOR EXOTIC MESON SEARCHES (SEE MAIN TEXT,
                    SEC. 3 AND TABLE 1), AS WELL AS THEORETICALLY BASED
                    SUGGESTIONS FOR EXPERIMENTS. NOTE THAT LIPKIN 73
                    PROPOSES EXPERIMENTS WHICH ARE CONCLUSIVE EVEN IF
                    NEGATIVE RESULTS ARE OBTAINED.

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                         REFERENCES FOR EXOTICS

                         REPORTS ON SEARCHES

ROSENFEL 68 PHILA.CONF.P.455   A.H.ROSENFELD                         (LRL)
DODD     69 PR 177 1991        +JOLDERSMA, PALMER, SAMIOS            (BNL)
CHO      70 PL 32 B 409        +DERRICK,JOHNSON,MUSGRAVE,+ (ANL+NWES+KANS)
GIACOMEL 70 PL  33 B 373       G.GIACOMELLI +   (BGNA+SACL+AMST+REHO+EPOL)
LYS      70 PR D 2 2525        J.LYS+                               (MICH)
ROSNER   70 EXP.MESON SPECTROSCOPY,ED. C.BALTAY AND A.H.ROSENFELD,P.499
BUHL     72 NP B 37 421        +CLINE,TERRELL                  (WISCONSIN)
COHEN    73 NP B 53 1          +FERBEL,SLATTERY,WERNER         (ROCHESTER)
DURUSOY  73 PL 45 B 517        +BAUBILLIER,GEORGE,ARMENISE,+   (LPNP+BARI)
ALAM     74 PL 53B 207         +BRABSON,GALLOWAY,+    (IND+PURD+SLAC+VAND)
COHEN    74  BOSTON            D.COHEN  REVIEW TALK                 (COLU)
OREN     74 NP B71 189         +COOPER,FIELDS,RHINES,WHITMORE,+  (ANL+OXF)
BALTAY   75 PL 57B 293         +CAUTIS,COHEN,KALELKAR,PISELLO,+(COLU+BING)
DAVIS    75 NP B96 426         +AMMAR,KROPAC,YARGER,+      (KANS+CCAC+ANL)

BRUNDIER 76 PL 64 B 107        BRUNDIERS,BRUN,FLURI,+  (FREIBURG+SACL+ETH)

BOUCROT  77 NP B 121 251       +NAVACH,RIVET,+         (LALO+CERN+CDEF+EPOL)
HOOGLAND 77 NP B 126 109       +GRAYER,HYAMS,BLUM,DITL,+  (AMST+CERN+MPIM)
HOOGLAND 77 NP B 126 109       +GRAYER,HYAMS,BLUM,DITL,+  (AMST+CERN+MPIM)
MOSER    77 NP B 129 28        F.L.MOSER                             (EFI)

ALAM     78 PRL 40 1685        +BAGGETT,BAGLIN,BONAMY+(IND+PURD+SLAC+VAND)
ARMSTRON 78 PL 77 B 447        AMSTRONG,FRAME,HUGHES,BIENLEIN+ (GLAS+DESY)

LEMOIGNE 79  PRE. DPHPE 79-16 +ABOLINS,BARATE+        (SACL+LOIC+SHMP+IND)

                         SUGGESTIONS FOR SEARCHES

ROSNER   68 PRL 21 950,1468    J.L.ROSNER                       (TEL-AVIV)
ROSNER   70 EXP.MESON SPECTROSCOPY,ED. C.BALTAY AND A.H.ROSENFELD,P.499
FAIMAN   73 PL 43 B 307        D.FAIMAN,G.GOLDHABER,Y.ZARMI         (CERN)
LIPKIN   73 PR D 7 2262        H.J.LIPKIN                   (ARGONNE+FNAL)

HOLMGREN 78 PL 77 B 304        +PENNINGTON                     (STOH+CERN)

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Data Card Listings

For notation, see key at front of Listings.

Baryons

N's and Δ's

Note on N's and Δ's

I. Determination of Resonance Parameters

Values of masses, widths, and branching ratios are obtained mainly from partial-wave analyses. In addition to a few comprehensive partial-wave analyses, there are numerous others which are based on somewhat incomplete data or cover only a limited energy range. We also include some information from production and total cross-section experiments. This can be valuable in establishing the existence of high mass bumps, but at the lower energies these experiments have limited statistics compared to formation experiments and it is seldom clear which of several states at similar masses is being observed.

There are two main problems in obtaining reliable resonance parameters. First there is often disagreement as to just what the values of the partial-wave amplitudes are. This problem is obviously related to the quality and quantity of the data and to the procedures used to determine the amplitudes. Secondly, even if smooth curves were available for the amplitudes, there would still be some parametrization-dependent ambiguity in deciding what the resonance parameters should be. From a theoretical standpoint the most unambiguously defined resonance parameters are the pole position and residue, and it has been found in practice that, given sufficiently precise partial-wave amplitudes, these quantities can be extracted in a stable and parametrization-independent way, in spite of the fact that they require an extrapolation away from the physical region. This point has been discussed in detail with regard to the Δ(1232) in previous editions of this review.[1,2] Although the best-determined pole parameters are those of Δ(1232), there are now a number of determinations for higher lying resonances which are included in the Data Card Listings. In most cases we specify pole parameters by giving the real and imaginary parts of the pole position and residue. It should be kept in mind that these real and imaginary parts tend to be highly correlated. For the residue, in particular, it is often the case that the absolute value is better determined than the phase. For further discussion see the corresponding references, e.g., NOGOVA 73, SPEARMAN 74, BALL 75, LICHTENBERG 75, VASAN 76, LONGACRE 77, ZIDELL 78, CUTKOSKY 79, and MIROSHNICHENKO 79.

The following sections of this mini-review contain discussions of various new developments in experimental non-strange baryon spectroscopy. For a thorough discussion of earlier results see our 1978 edition[3] and the reviews of K. Lanius[4] and S. Ozaki.[5]

At the beginning of the Data Card Listings for N's and Δ's, we present a table giving our evaluation of the status of the N and Δ resonances based on information contained in the Listings. In the Table of Particle Properties, we do not quote values and errors for most parameters, but give only ranges for masses and widths in order to emphasize that in some cases these parameters are quite poorly determined. When in doubt about the reliability of a particular parameter, we choose the range quoted in the Tables to be conservatively large.

References for Section I

1. Particle Data Group, Rev. Mod. Phys. 43, S114 (1971).
2. Particle Data Group, Phys. Lett. 39B, 103 (1972).
3. Particle Data Group, Phys. Lett. 75B, No. 1 (1978).
4. K. Lanius, in Proceedings of the 18th International Conference on High Energy Physics, (Tbilisi, 1976), Vol. I, pg.C45.
5. S. Ozaki, in Proceedings of the 19th International Conference on High Energy Physics, (Tokyo, 1978), pg.101.

For other references see the Data Card Listings.

II. Two-Body Partial-Wave Analyses and New Resonances

Several new partial-wave analyses have appeared, and older analyses have been published in final form, since our 1978 edition.[1] In the $\pi N \to \pi N$ reactions we have the analyses of CUTKOSKY 79, HOEHLER 79, HENDRY 78, ZIDELL 78, and Chew.[2] CUTKOSKY 79 analyzes $\pi N \to \pi N$ reactions in the mass range 1300-2150 MeV, and supersedes the analysis of CUTKOSKY 76 which concentrated on I = 3/2 resonances in a narrower range. HOEHLER 79 is the published version

Baryons

N's and Δ's

Data Card Listings

For notation, see key at front of Listings.

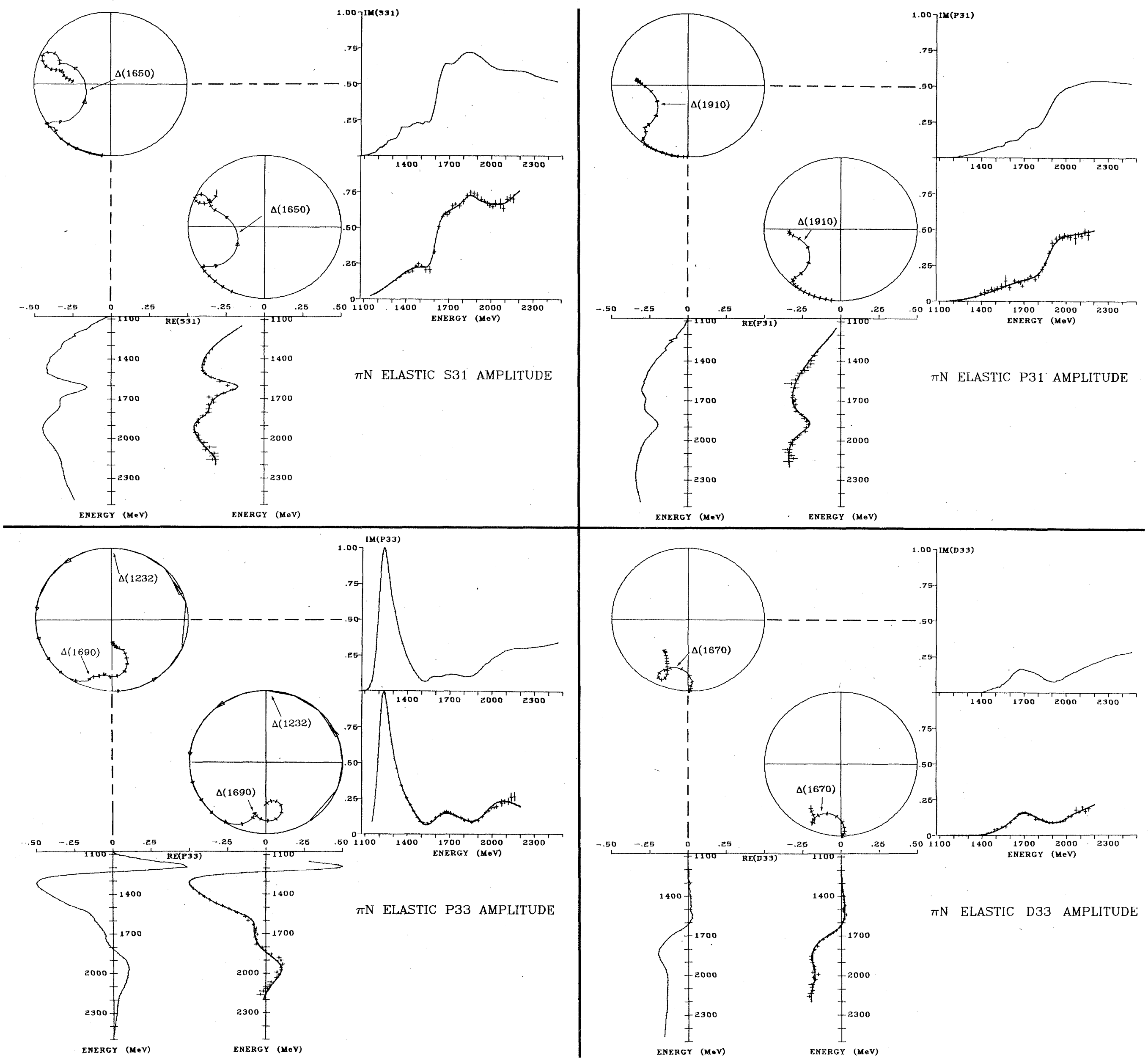

Fig. II.1. Amplitudes for I = 3/2 πN elastic scattering in the J = 1/2 and J = 3/2 waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at integer multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from elastic threshold to 2500 MeV. The established resonances in these waves are indicated on the Argand plots. The results of two different analyses are shown; the energy axes for the two analyses are aligned for ease of comparison. The lower Argand plot for each wave is from CUTKOSKY 79 (results of energy-independent fitting are shown as data points; the curves show an energy-dependent fit). The upper plot for each wave is from HOEHLER 79.

Data Card Listings

For notation, see key at front of Listings.

Baryons

N's and Δ's

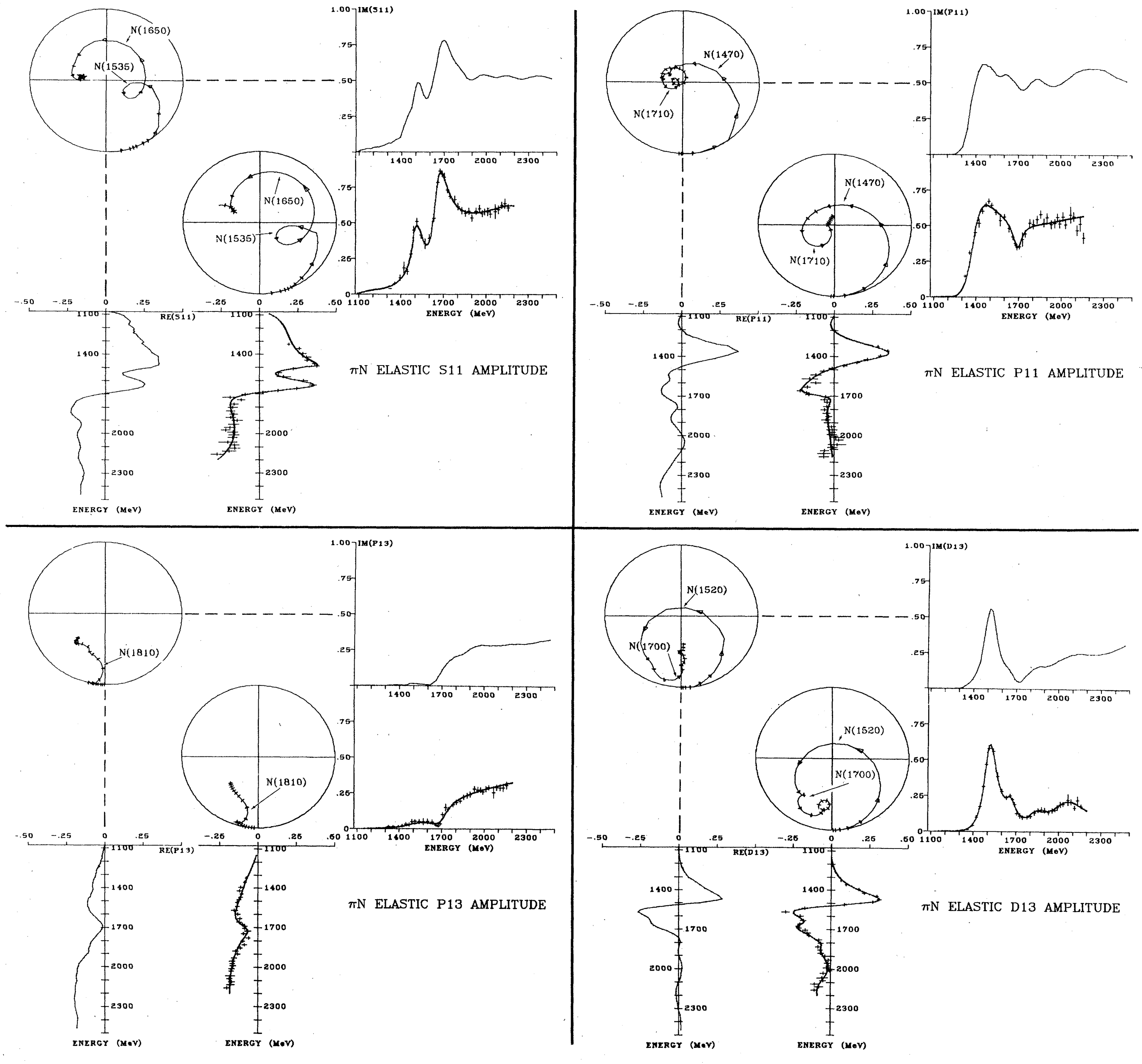

Fig. II.2. Amplitudes for I = 1/2 πN elastic scattering in the J = 1/2 and J = 3/2 waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at integer multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from elastic threshold to 2500 MeV. The established resonances in these waves are indicated on the Argand plots. The results of two different analyses are shown; the energy axes for the two analyses are aligned for ease of comparison. The lower Argand plot for each wave is from CUTKOSKY 79 (results of energy-independent fitting are shown as data points; the curves show an energy-dependent fit). The upper plot for each wave is from HOEHLER 79.

Baryons

N's and Δ's

Data Card Listings

For notation, see key at front of Listings.

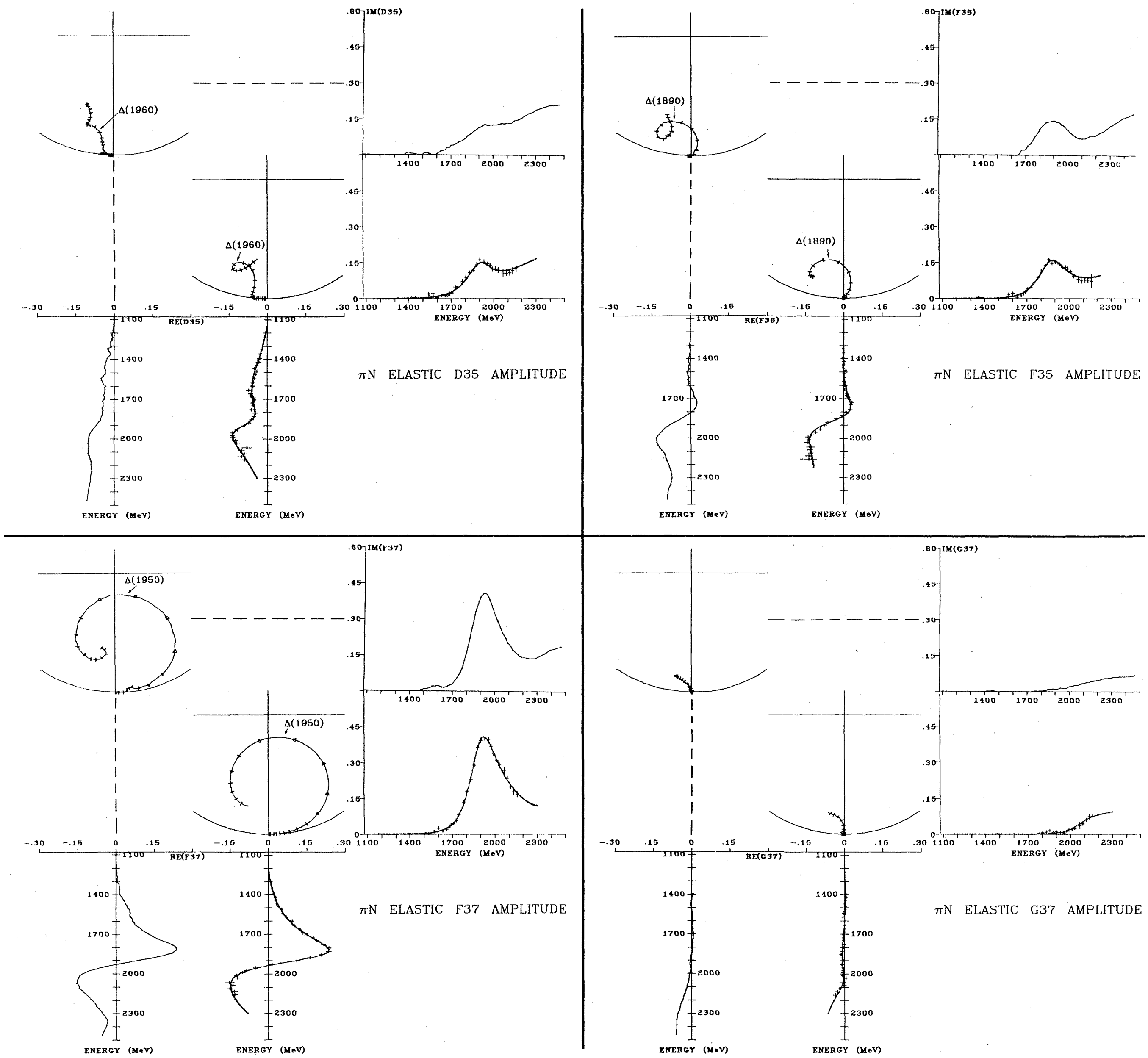

Fig. II.3. Amplitudes for I = 3/2 πN elastic scattering in the J = 5/2 and J = 7/2 waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at integer multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from elastic threshold to 2500 MeV. The established resonances in these waves are indicated on the Argand plots. The results of two different analyses are shown; the energy axes for the two analyses are aligned for ease of comparison. The lower Argand plot for each wave is from CUTKOSKY 79 (results of energy-independent fitting are shown as data points; the curves show an energy-dependent fit). The upper plot for each wave is from HOEHLER 79.

Data Card Listings

For notation, see key at front of Listings.

Baryons

N's and Δ's

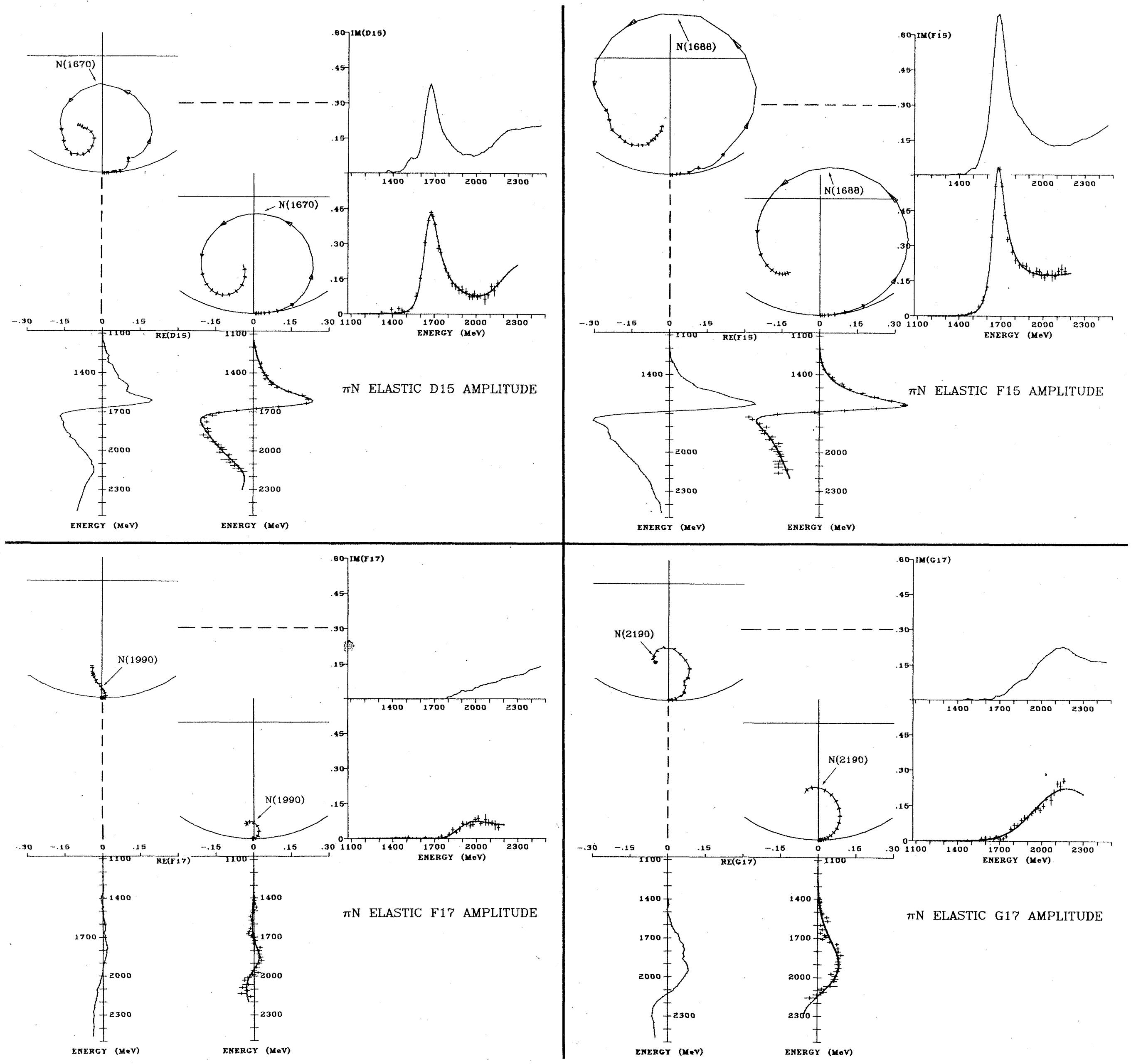

Fig. II.4. Amplitudes for $I = 1/2$ πN elastic scattering in the $J = 5/2$ and $J = 7/2$ waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at integer multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from elastic threshold to 2500 MeV. The established resonances in these waves are indicated on the Argand plots. The results of two different analyses are shown; the energy axes for the two analyses are aligned for ease of comparison. The lower Argand plot for each wave is from CUTKOSKY 79 (results of energy-independent fitting are shown as data points; the curves show an energy-dependent fit). The upper plot for each wave is from HOEHLER 79.

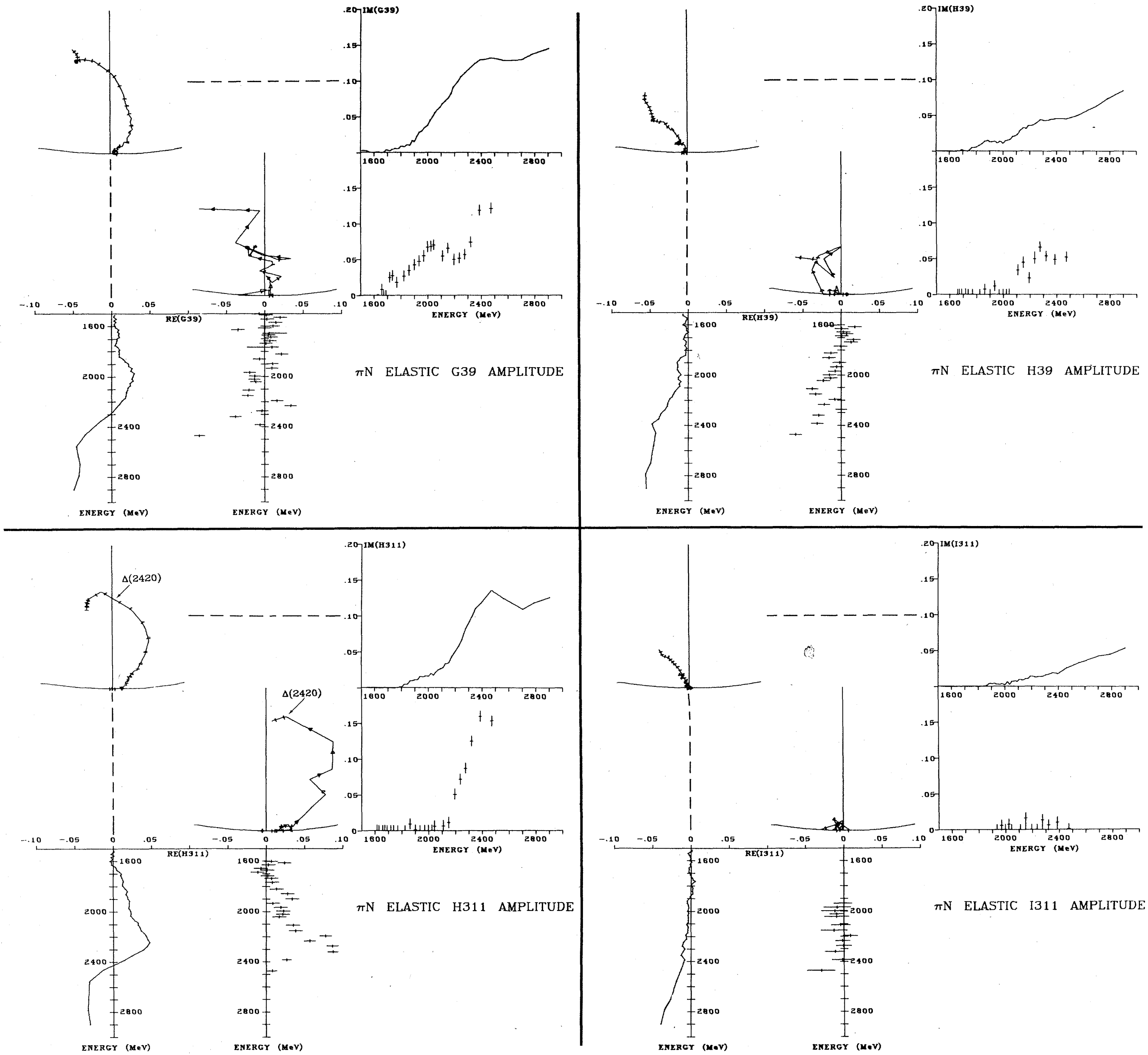

Fig. II.5. Amplitudes for I = 3/2 πN elastic scattering in the J = 9/2 and J = 11/2 waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at integer multiples of 50 MeV and a base-to-tip length of 5 MeV. All energy axes run from 1500 to 3000 MeV. The established resonance in the $H_{3\,11}$ wave is indicated on its Argand plots. The results of two different analyses are shown; the energy axes for the two analyses are aligned for ease of comparison. The lower Argand plot for each wave is from AYED 76; the upper plot is from HOEHLER 79.

Data Card Listings

For notation, see key at front of Listings.

Baryons

N's and Δ's

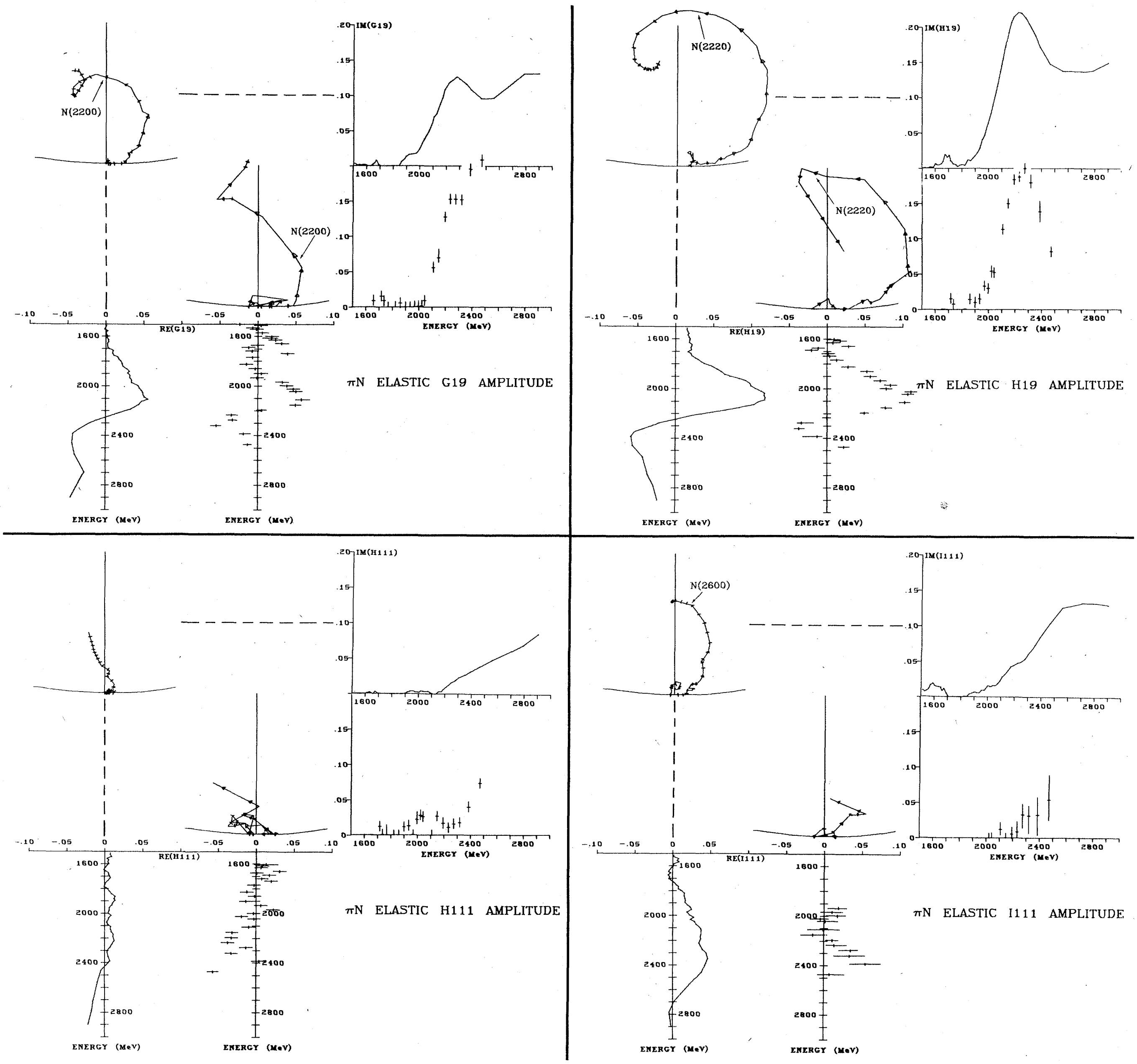

Fig. II.6. Amplitudes for I = 1/2 πN elastic scattering in the J = 9/2 and J = 11/2 waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at integer multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from 1500 to 3000 MeV. The established resonances in these waves are indicated on the Argand plots. The results of two different analyses are shown; the energy axes for the two analyses are aligned for ease of comparison. The lower Argand plot for each wave is from AYED 76; the upper plot is from HOEHLER 79.

of the analysis made available to us by Pietarinen[3] for our 1978 edition, and referred to there as PIETARINEN 78. This analysis covers a wide range, with claims for resonance masses as large as 3000 MeV. Both CUTKOSKY 79 and HOEHLER 79 make extensive use of analyticity in their parametrizations, but in quite different ways. The analysis of HENDRY 78 concentrates on the most peripheral high-spin, high-mass resonances, and extracts these using a diffractive + peripheral ansatz for the high energy behavior of the $\pi N \to \pi N$ amplitudes in the impact-parameter representation. Resonances with spin as high as 21/2 and mass as high as 4100 MeV are reported. At lower energies ZIDELL 78 report new determinations of the Δ^0 and Δ^{++} pole positions, and Chew[2] uses a Barrelet-zero technique to analyze $\pi^+ p \to \pi^+ p$ data below 2300 MeV.

Two analyses of inelastic reactions have also been reported. BAKER 79 analyzes $\pi^- p \to \eta n$ between 1500 and 2250 MeV, and SAXON 80 analyzes $\pi^- p \to K^0 \Lambda$ below 2300 MeV. Both are energy-dependent analyses in which the existence (and sometimes the masses and widths) of N resonances are taken from $\pi N \to \pi N$ analyses, and the couplings to the inelastic reaction are determined.

In 1978 we added five new N and Δ resonances to the Baryon Table (see Ref. 1). These have been strengthened by more recent results, and two have been promoted to 4-star status. This year we are adding one more nucleon resonance, the F17 N(1990). The results of CUTKOSKY 79 and HOEHLER 79 for this resonance are illustrated in Fig. II.4. It was also observed by BAKER 79, but not by SAXON 80.

An important change within the Listings, which does not yet appear in the Table, is the further clarification of the P33 amplitude in the range 1500-2000 MeV. The Δ(1690) was added to the Table in 1978, and it seemed likely that there was another P33 resonance near 2000 MeV. Most of the evidence for this effect was contained in the rather confused listing for the Δ(2160). This year we have been able to extract the information relevant to the P33 partial wave from Δ(2160), combine it with newer information from CUTKOSKY 79 and HOEHLER 79, and list the new 2-star P33 resonance Δ(1960). Another important change in the Listings this year is the addition of many 1-star high-spin, high-mass resonances from the analyses of HOEHLER 79 and HENDRY 78.

<u>References for Section II</u>

1. Particle Data Group, Phys. Lett. <u>75B</u>(1) (1978).
2. D. M. Chew, LBL-5306 and LBL-10075 (1979).
3. E. Pietarinen, private communication (1978).

For other references see the Data Card Listings.

III. <u>The $\pi N \to \pi\pi N$ Channel</u>

In general, the 2 → 3-body process, ab → cde, is described by the center-of-mass energy, W, three angles, α, β, and γ, and two subenergies, w_{cd} and w_{de}. Thus, unlike 2 → 2-body reactions, fits at single values of W cannot be parametrized in terms of a set of constants without introducing some assumptions into the analysis. All fits to $\pi N \to \pi\pi N$ use the isobar model, which notes that almost all events for the reaction lie in bands for quasi-two-body processes in the Dalitz plot. It is therefore assumed that there is no pure three-body interaction and that the reaction proceeds by the formation of a two-body state which decays into three bodies.

The basic form used is

$$T(\pi N \to \pi\pi N) = \sum \Big\{ T^{JILL'}_{\Delta\pi}(W)\; BW_{\Delta}(w_{\pi N})\; X^{JILL'}_{\Delta\pi} + T^{JILL'}_{N^*\pi}(W)\; BW_{N^*}(w_{\pi N})\, X^{JILL'}_{N^*\pi} + T^{JILL'}_{\rho N}(W)\; BW_{\rho}(w_{\pi\pi})\; X^{JILL'}_{\rho N} + T^{JILL'}_{\epsilon N}(W)\; BW_{\epsilon}(w_{\pi\pi})\; X^{JILL'}_{\epsilon N} \Big\},$$

where in present analyses $\Delta = \Delta(1232)$, $N^* = N^*(1470)$, $\rho = \rho(770)$, and ε is the S-wave, I=0 ππ enhancement (although not all the isobars may be included in the different analyses). Here, BW denotes the appropriate Breit-Wigner or corresponding two-body amplitude from πN or ππ analyses, and X is a well-defined function containing all the angular information. The decay of the resonances formed in the reaction is given by the partial-wave amplitudes, $T^{JILL'}_{\Delta\pi}$, etc., with J giving the total angular momentum and I the total isospin of the state formed. L and L' are respectively the orbital angular momenta of the initial two-body and final quasi-two-body states. $\vec{J} = \vec{L} + \vec{S} = \vec{L}' + \vec{S}'$, with S and S' as the initial and final total spins. In the case of the ρN amplitude, it is necessary to add the suffix 2S', equal to 1 or 3, to indicate the total ρN spin. The partial-wave amplitudes are frequently denoted by Δ L L' 2I 2J, N* L L' 2I 2J, $\rho_{2S'}$ L L' 2I 2J, and ε L L' 2I 2J.

The Data Card Listings contain the results of four analyses.

LONGACRE 75 (LBL-SLAC) is an analysis using 200K events for $\pi^-p \to \pi^-\pi^0p$, $\pi^-\pi^+n$ and $\pi^+p \to \pi^+\pi^0p$ with 1300 MeV ⩽ W ⩽ 2000 MeV. Approximate unitarity constraints are imposed in the form of a simplified K-matrix formalism that links the ππN channel to the πN channel. This gives smooth solutions and eliminates the overall phase ambiguity that can occur at each energy. The Δπ, ρN, and εN isobar states are included. Couplings and T-matrix pole positions are given for 14 resonances. A fuller description is given in the 1974 edition of Review of Particles Properties.

LONGACRE 77 (Saclay) is a coupled-channel analysis similar to LONGACRE 75 that fits 100K events for 1380 MeV ⩽ W ⩽ 1740 MeV. The couplings and pole positions of 16 resonances are measured including those of the $P_{13}(1540)$ and $P_{31}(1550)$, which are suggested for the first time in this analysis and have not yet been seen in any other channel.

NOVOSELLER 78 (California Inst. of Technology) is an analysis of $\pi^-p \to \pi^-\pi^0p$, $\pi^-\pi^+n$ and $\pi^+p \to \pi^+\pi^0p$ for 1630 MeV ⩽ W ⩽ 1990 MeV, based on the LBL-SLAC energy-independent analysis.[1] Again the Δπ, ρN, and εN isobar states are used, but the resonances are fitted by a simple Breit-Wigner rather than the K-matrix formalism of LONGACRE 75. This analysis considers the criticism made of earlier analyses that they ignore the effects of one-pion-exchange with ππ rescattering. This is used to calculate the higher partial waves, and it is concluded that it improves the fit for W ⩾ 1800 MeV and helps eliminate the phase ambiguity. Another study of the importance of one-pion-exchange has been made by Aaron et al.,[2] who also find that it can give important corrections to the angular dependence. NOVOSELLER 78 quotes two solutions, the second including the effects of π exchange. They are given in the Data Card Listings as, respectively, fits to LONGACRE 75 and NOVOSELLER 78.

BARNHAM 79 (see also Ref. 3) is an analysis at Imperial College, London, of 44K events for $\pi^+p \to \pi^+\pi^0p$, $\pi^+\pi^+n$ for 1440 MeV ⩽ W ⩽ 1700 MeV, thus concentrating on the Δ resonances and using data not available to the other analyses. It considers that the reaction proceeds by the πΔ, ρN, and πN*(1470) isobar states, the last one being necessary to account for the difference between the $\pi^+\pi^0p$ and $\pi^+\pi^+n$ cross sections. Also included is the effect of one-pion-exchange leading to the S-wave ππ state with I = 2. The phase ambiguity is resolved by requiring the πΔ amplitude for the $D_{33}(1670)$ to have a Breit-Wigner phase. The parameters of four resonances are evaluated, including the $P_{31}(1550)$, but since some of the data used are also used by LONGACRE 77 it is not clear that the existence of this resonance is confirmed.

It is difficult to assess the accuracy with which the couplings of the resonances to the final isobar states are known, but those that are indicated in the Data Card Listings as being considered well determined in LONGACRE 77 do, in general, at least agree in sign with the values from other analyses, although some of the ρ_3 couplings have not been measured elsewhere. The group at Imperial College also claim to get a clear measurement of the signs of ρ_1SS31, ρ_1DD33, and N*PP33.

All existing isobar models can be criticized because they neglect possible subenergy dependence of the partial-wave amplitudes and because it can be shown[4] that this is not consistent with unitarity. This problem has been studied by Aitchison and Brehm,[5] who derive an isobar expansion that is consistent with Bose symmetry and with subenergy analyticity and unitarity. The resulting coupled integral equations are suitable for both dynamical and phenomenological studies of πN → ππN. They estimate the subenergy corrections to the isobar model and conclude that such corrections may not be significant for existing isobar fits but could become important with improved experimental data.[6] A rough estimate of these corrections has also been made by the Imperial College group,[3] who find that they are small.

References for Section III

1. D.J.Herndon, R.Longacre, L.R.Miller, A.H.Rosen-

feld, G.Smadja, P.Söding, R.J.Cashmore, and D.W.G.S.Leith, Phys. Rev. D11, 3183 (1975).
2. R.Aaron, R.D.Amado, R.A.Arndt, Y.Goradia, D.C.Teplitz, and V.L.Teplitz, Phys. Rev. D16, 50 (1977).
3. K.W.J.Barnham, in Proceedings of the Topical Conference on Baryon Resonances, Oxford, 1976, edited by R.T.Ross and D.H.Saxon, pg.109.
4. R.Aaron and R.D.Amado, Phys. Rev. Lett. 31, 1157 (1973).
5. I.J.R.Aitchison and J.J.Brehm, Phys. Rev. D20, 1119 (1979).
6. I.J.R.Aitchison and J.J.Brehm, Phys. Rev. D20, 1131 (1979).

IV. Photon Couplings

IVa. Photoproduction

The couplings of γN to N* and Δ resonances can be studied in any formation process in which the coupling to the final strong decay channel is well known. In practice, this limits the sources of such couplings to the analysis of single-pion photoproduction, for which the final state has been extensively studied in the phase-shift analysis of elastic πN scattering. There are also more experimental data for single-pion photoproduction than for any other photoproduction reactions. All analyses rely heavily on information from πN elastic phase-shift analyses for values of the masses and widths of the resonances. These are fitted in only a few photoproduction analyses, and even in these it is necessary to rely on the πN phase-shift analyses for a prior knowledge of the existence of a resonance and for starting values for its mass and width. However, the photoproduction results are of interest since they give information for the resonance states with charge of +1.

The most important analyses of single-pion photoproduction are reviewed below. The formalism has been previously described[1] and readers are referred there for additional information. There are three basic methods of analysis. All have had to cope with the difficulty of having four independent complex spin amplitudes at any energy and production angle, and of having only up to four independent experimental measurements. The recent measurements of the G and H observables[2] have not yet been used in any analysis.

(a) Simple Isobar Model

This is the simplest form of energy-dependent analysis. The partial waves are parametrized as a smooth background to which Breit-Wigner resonant structure is added. Usually, the electric, but not magnetic, Born terms are included explicitly to reproduce the forward peak in charged-pion production. This method is sufficiently flexible to give excellent fits to the experimental data, but there are, in principle, difficulties concerning the uniqueness of the solution due to the large number of partial waves that are involved. This is overcome by the form of the parametrization, but it is not clear how this may bias the solution. The most extensive analysis of this type is METCALF 74, which is an extension of the earlier Walker analysis.[3] It fits $\gamma p \to \pi^+ n$, $\pi^0 p$ and $\gamma n \to \pi^- p$ from the first to the fourth resonance region. FELLER 76 fits only $\gamma p \to \pi^+ n$ and $\pi^0 p$ from the first to the third resonance region but uses data not available to the earlier analysis. Other isobar analyses (ROSSI 73, HEMMI1 73, HEMMI2 73, BENEVENTANO 74, and KRIVETS 74[4]) have been made on a significantly smaller scale using small and sometimes restricted data sets.

(b) Fixed-t Dispersion Relations (FTDR)

This technique uses the apparent resonant dominance of the photoproduction amplitudes to get a relatively simple parametrization of their imaginary parts. Fixed-t dispersion relations are used to calculate the real parts without the introduction of other free parameters, or, in some cases, with only a relatively small number of additional parameters. This significantly reduces the possibility of multiple solutions and automatically satisfies the requirements of analyticity. However, the method is relatively inflexible compared to the isobar model, giving poorer fits. Also, as has been described in NOELLE 78 and elsewhere,[5] the divergence of the partial-wave expansions for the dispersion integrals does not allow the use of experimental data at all angles above about the third resonance region. Not all analyses include the constraints of unitarity and time-reversal invariance as given

Data Card Listings

For notation, see key at front of Listings.

Baryons

N's and Δ's

by Watson's theorem.[6]

FTDR analyses have been made by groups at Berkeley (MOORHOUSE 73, KNIES 74, and MOORHOUSE 74), at Lancaster (DEVENISH 73, DEVENISH2 74), at Glasgow (CRAWFORD 75, BARBOUR 76, and BARBOUR 78) and at Yerevan (AZNAURYAN 77). NOELLE 78 is a hybrid analysis incorporating FTDR in a coupled-channel isobar model.

(c) Energy-Independent Analysis

These evaluate the partial waves by making independent fits over a range of essentially single energies, and are thus the least biased of all the techniques employed. It is necessary to use Watson's theorem to fix the complex phases of the partial waves in order to get a unique solution. Due to inelasticity, this becomes difficult above the first resonance region, and only BERENDS 77 extends into the second resonance region. This analysis suggests in particular that the $A^p_{3/2}$ coupling for the $D'_{13}(1520)$ from the energy-dependent analyses is too large by a factor of almost two due to the omission of non-resonant background.

New Analyses in the Data Card Listings

AZNAURYAN 77 is an FTDR analysis of $\gamma p \to \pi^0 p$ from threshold to a laboratory photon energy of 1.2 GeV. NOELLE 78, as described, is a hybrid isobar and FTDR analysis of the first and second resonance regions. BARBOUR 78 is an FTDR analysis that combines a partial-wave analysis for center-of-mass energies, W, up to 2.5 GeV with an amplitude analysis at higher energies to reduce the uncertainty in the FTDR from the high energy parts of the dispersion integrals. Data at all accelerator energies are fitted, and, as in the other Glasgow analyses, the resonance masses and widths are evaluated with the couplings. MIROSHNICHENKO 79 is based on an earlier energy-independent analysis[7] and measures the pole position of the Δ^+, $P_{33}(1232)$, resonance.

Resonance Couplings and Errors in the Data Card Listings

The Data Card Listings give the results of all recent and extensive analyses. If no error is given, only a unique result has been quoted. The Berkeley analyses and CRAWFORD 75 give for the errors the spread of solutions around a central value. The

TABLE IV.1. The average of the couplings from MOORHOUSE 74, KNIES 74, METCALF 74, DEVENISH2 74, FELLER 76, BERENDS 77, and BARBOUR 78. The errors take into account both statistical errors and the variation of values over the analyses. Where no error is shown, it is considered that there are too few analyses to make a reliable estimate.

		Helicity Couplings $(\mathrm{GeV})^{-1/2} \times 10^{-3}$	
Resonance	Helicity	A^p_λ	A^n_λ
$P'_{11}(1470)$	1/2	-77 ± 10	35 ± 22
$D'_{13}(1520)$	1/2	-11 ± 8	-75 ± 15
	3/2	151 ± 37	-131 ± 17
$S'_{11}(1535)$	1/2	60 ± 19	-56 ± 33
$D'_{15}(1670)$	1/2	20 ± 12	-30 ± 26
	3/2	20 ± 11	-54 ± 27
$F'_{15}(1688)$	1/2	-4 ± 16	24 ± 11
	3/2	133 ± 23	-20 ± 20
$S''_{11}(1700)$	1/2	45 ± 21	-22 ± 17
$D''_{13}(1700)$	1/2	-15 ± 35	-4 ± 45
	3/2	8 ± 25	12 ± 30
$P''_{11}(1780)$	1/2	2 ± 40	9 ± 50
$P''_{13}(1810)$	1/2	33 ± 54	9 ± 40
	3/2	-39 ± 43	-10 ± 55
$F_{17}(1990)$	1/2	40 ± ?	-69 ± ?
	3/2	4 ± ?	-72 ± ?
$G_{17}(2190)$	1/2	-30 ± ?	-85 ± ?
	3/2	180 ± ?	7 ± ?
		A^Δ_λ	
$P'_{33}(1232)$	1/2	-141 ± 7	
	3/2	-259 ± 10	
$S'_{31}(1650)$	1/2	39 ± 45	
$D_{33}(1670)$	1/2	63 ± 43	
	3/2	58 ± 39	
$P''_{33}(1690)$	1/2	-8 ± 20	
	3/2	-7 ± 25	
$F_{35}(1890)$	1/2	35 ± 20	
	3/2	-7 ± 60	
$P''_{31}(1910)$	1/2	-14 ± 23	
$F_{37}(1950)$	1/2	-71 ± 15	
	3/2	-101 ± 45	
$D_{35}(1960)$	1/2	-62 ± ?	
	3/2	19 ± ?	

Baryons

N's and Δ's

Data Card Listings

For notation, see key at front of Listings.

Lancaster group give as an error the change of value for each coupling that is required to increase the "best possible" χ^2 by 1%. METCALF 74, FELLER 76, and AZNAURYAN 77 quote similar errors. In BARBOUR 78, the point of view is taken that the systematic variations due to the different methods of analyses are at least as significant as the purely statistical errors that are usually given. Thus, the errors quoted are obtained by comparison with other analyses as well as from the random variation of the parameters over a number of fits.

In the compilation of couplings given in Table IV.1, the errors given are calculated in a similar manner from both the statistical errors quoted in the analyses used and from the spread of results over the analyses.

References for Section IVa

1. Particle Data Group, Rev. Mod. Phys. 48, S157 (1976).
2. P.J.Bussey et al., Daresbury preprint DL/P290E (1979).
3. R.L.Walker, Phys. Rev. 182, 1729 (1969).
4. A.G.Krivets et al., Sov. J. Nucl. Phys. 20 430 (1975).
5. R.C.E.Devenish, D.H.Lyth, and W.A.Rankin, Daresbury report DNPL/P109 (1972).
6. K.M.Watson, Phys. Rev. 95, 228 (1954).
7. I.I.Miroshnichenko et al., Sov. J. Nucl. Phys. 26, 52 (1977).

IVb. Electroproduction in the Resonance Region

(by F. Foster, Lancaster University, April 1978)

Both the quantity and quality of the data continue to improve in this interesting but somewhat unfashionable corner of the ν, Q^2 plane. Most experiments now use the coincidence technique: detecting the scattered electron to fix the energy and momentum transfer, together with one of the final state hadrons ($p,\pi^{\pm}$). By this method the virtual photoproduction differential cross sections for particular exclusive channels can be determined.

At the date of the 1976 Review many excellent data sets were already available. These included π^0 production in the first resonance region from DESY,[1,2] the Lancaster-Manchester group at Daresbury,[3] and Bonn University.[4] There was also good π^0 data in the second resonance region[5] and forward π^+ data in the second and third resonance regions from Lancaster-Manchester.[6] Much interest was generated by the η data from Daresbury, DESY, and Bonn, which is a unique indicator for the $S'_{11}(1535)$ resonance.[7-9] The total cross-section measurements from DESY,[10] Bonn,[11] and Stanford[12] gave essential information on the Q^2 variation of the resonance "peak" heights in relation to the background, and demonstrated that the longitudinal-to-transverse ratio σ_L/σ_T was everywhere very close to zero.

During the past two years much new information has become available. In particular we have the detailed data sets from DESY on single π^+ and π^0 production in the second and third resonance regions[13,14] at Q^2 values of 0.6 and 1.0 GeV^2, and new η data near the $S'_{11}(1535)$ from DESY[15,16] at 0.6, 1.0, 2.0, and 3.0 GeV^2 and Bonn[17] at Q^2 of 0.4 GeV^2. By changing the virtual photon polarization, both groups have succeeded in measuring the longitudinal excitation of the S_{11} resonance with the results: $\sigma_L/\sigma_T = 0.15\pm0.18$ ($Q^2=0.6$),[15] -0.06 ± 0.16 ($Q^2 = 1.10$),[16] 0.16 ± 0.10 ($Q^2=0.4$).[17] The Lancaster-Manchester group has taken a large amount of data on π^- and π^+ production from a deuterium target over the second and third resonance regions at Q^2 values 0.5 and 1.0 GeV^2. From this data it will be possible to extract the differential cross sections $\gamma_v n \to p\pi^-$, which are essential to the understanding of the multipole couplings to the isospin-1/2 resonances. Preliminary data were available at the Hamburg conference[18] for the π^-/π^+ ratio at $Q^2=0.5$ GeV^2 in the forward direction, and estimates were presented of the neutral $D'_{13}(1520)$ multipole couplings.[19]

Theoretical analyses of the data sets to extract resonance multipole couplings necessarily rely on fixed-t dispersion-relation calculations which relate the real (background) and imaginary (resonant) parts of these matrix elements. R. C. E. Devenish and D. H. Lyth[20] incorporated the constraints into an energy-dependent fitting procedure and produced the first estimates of second and third resonance multipoles up to $Q^2=1.5$ GeV^2 using the Lancaster-Manchester[5,6] and preliminary DESY π^0, π^+, and η data together with total cross-section measurements. Since then, Gayler[21] has used the final DESY data in the same fitting routines and has produced improved results on the couplings to the $S'_{11}(1535)$, $D'_{13}(1520)$, $F'_{15}(1688)$, and $P'_{11}(1470)$ resonances.

The present status of the couplings to the more prominent resonant states may be summarized as follows:

P'_{33}(1232): There is no change from previous reviews. However, Gayler remarks[21] that while the resonance appears to be a dominantly magnetic (quark spin flip) excitation, the background, which forms an increasing fraction of the single-pion cross section as Q^2 increases, is dominantly helicity-1/2 in the $\gamma_v p$ system. This is to be expected on the basis of the quark parton model and duality.

D'_{13}(1520): It is firmly established[6,13,14,21] that the transverse helicity-1/2 excitation increases rapidly as Q^2 increases from 0 to 1.0 GeV^2. The rate of increase observed depends on the details of the fitting procedures used, but is consistent with the magnetic coupling falling slowly and the electric coupling falling like a "dipole," almost as one would expect from a naive harmonic oscillator quark model.[22]

S'_{11}(1535): The new data[14-17] establish beyond doubt that the excitation of this resonance falls less rapidly than its SU(6) partner $D'_{13}(1520)$ and the excitation is dominantly transverse. At $Q^2 = 0$, contributions of the D_{13} and S_{11} are in the ratio 4:1, while at $Q^2 = 3.0$ GeV^2 the ratio becomes an amazing 1:2. Thus the second resonant peak in total cross-section measurements at high Q^2 is dominated by the $S'_{11}(1535)$ — this may account for possible small changes in the observed shape as Q^2 increases.

P'_{11}(1470): The situation here is fluid; although there are no clear signals for this resonance, some analyses[21] do require a significant contribution at $Q^2 = 1.0$ GeV^2. New π^0 and π^+ data from Lancaster-Manchester below the second resonance and from DESY at high Q^2 may clarify the position.

F'_{15}(1688): Here again the helicity-1/2 to helicity-3/2 ratio is observed to increase with Q^2 as we expect from the quark model.

Some progress has been made in understanding the phenomenology of resonance electroproduction within the framework of $SU(6)_w$ symmetry.[23] Cashmore et al.,[24] for example, have shown that radiative transitions between the nucleon and members of the $\{70,1^-\}$ multiplet are consistent with only three independent amplitudes, corresponding to quark orbit flip, spin flip, and simultaneous spin-orbit excitation. (Note that the spin-orbit term is normally neglected in "naive" quark model calculations.[22]) It is necessary to find out if this relatively simple structure persists as Q^2 increases and, if it does, to determine the Q^2 variation of the three amplitudes. Using mainly the amplitudes connecting the proton and the charged D_{13} and S_{11} resonances, Foster[25] and Alcock et al.[26] have shown that all three excitation terms are necessary to describe electroproduction at Q^2 values up to 1 GeV^2. The orbit flip term falls rapidly, while the spin flip term remains almost constant as Q^2 increases (just like the simple quark model predictions), causing the observed helicity change-over. The spin-orbit term has an intermediate variation with Q^2 and appears to be influential in causing the S_{11} to dominate the D_{13} at Q^2 values above 0.5 GeV^2. To be sure that the three terms are sufficient to describe electroproduction of the $\{70,1^-\}$ multiplet we will have to await accurate determination of more charged resonance multipoles or some measurements of the neutral isospin-1/2 resonance multipoles. The preliminary data from Lancaster-Manchester[18,19] on the process $\gamma_v n \to \pi^- p$ near the second resonance give results for M^n_{2-} and E^n_{2-} which are in fair agreement with the $SU(6)_w$ scheme.[25]

References for Section IVb

1. W. Albrecht et al., Nucl. Phys. B25, 1 (1970).
2. J. C. Adler et al., Nucl. Phys. B46, 573 (1972).
3. R. Siddle et al., Nucl. Phys. B35, 93 (1971).
4. K. Bätzner et al., Nucl. Phys. B76, 1 (1974).
5. W. J. Shuttleworth et al., Nucl. Phys. B45, 428 (1972).
6. E. Evangelides et al., Nucl. Phys. B71, 381 (1974).
7. P. S. Kummer et al., Phys. Rev. Lett. 30, 873 (1973).

8. J. C. Adler et al., Nucl. Phys. B91, 386 (1975).
9. U. Beck et al., Phys. Lett. 51B, 103 (1974).
10. F. W. Brasse et al., Nucl. Phys. B110, 413 (1976).
11. M. Kobberling et al., Nucl. Phys. B82, 201 (1974).
12. S. Stein et al., Phys. Rev. D12, 1884 (1975).
13. J. C. Adler et al., Nucl. Phys. B99, 1 (1975).
14. J. C. Adler et al., Nucl. Phys. B105, 253 (1976).
15. F. W. Brasse et al., DESY preprint 77/73.
16. F. W. Brasse et al., DESY preprint 77/?.
17. H. Breuker et al., Bonn preprint BONN-1R-77-11.
18. J. Wright et al., Contribution to 1977 Hamburg Symposium, DL/P276.
19. R. Marshall, Invited talk at 1977 Hamburg Symposium.
20. R. C. E. Devenish and D. H. Lyth, Nucl. Phys. B93, 109 (1975).
21. J. Gayler, Proc. Oxford Conference on Baryon Spectroscopy, edited by R. Ross, D. Saxon, 1976; also DESY 76/42.
22. E.g., F. Ravndal, Phys. Rev. D4, 1466 (1971); also F. Foster, Proc. XVII Internat'l. Conf. London (1974), edited by J. R. Smith II, p.163.
23. A. J. G. Hey, Proc. Oxford Conf. on Baryon Spectroscopy, edited by R. Ross, D. Saxon, 1976.
24. R. J. Cashmore et al., Nucl. Phys. B98, 337 (1975).
25. F. Foster, Contribution to 1977 Hamburg Symposium; also Ref. 19.
26. J. W. Alcock, W. N. Cottingham, and A. C. Davis, Phys. Lett. 69B, 457 (1977).

V. Production Experiments

It is difficult to draw firm conclusions about N and Δ resonance properties from production experiments because each prominent bump seen in production is generally a coherent superposition of several resonances plus non-resonant background. However, production and formation experiments are clearly closely related, and we give parameters obtained from production experiments in the Listings, although they are not used in the Tables. This section contains a brief review of the main results of recent N and Δ production experiments. We concentrate on diffractive production of πN and ππN systems as this is where most of the recent experimental activity has been.

Data on the exclusive channels NN → NNπ and NNππ at high energy are now available, both from FNAL (BIEL 78) and the CERN ISR (WEBB 75, DEKERRET 76, and GOGGI 79). Double diffraction dissociation reactions have also been studied at the ISR (GOGGI1 78). The diffractively produced πN and ππN systems have mass shapes which are remarkably similar to those observed at lower momenta.

The low mass πN system is dominated by a broad bump peaking around 1.35 GeV, on which may be superimposed other structures at 1.5 and 1.7 GeV. The 1.35 GeV bump is produced more peripherally than those at 1.5 and 1.7 GeV (DEKERRET 76, HARRIS 77, BIEL 78, and CHADWICK 78). The two higher mass peaks are probably associated with the $D'_{13}(1520)$ and $F'_{15}(1688)$, respectively.

There is mounting evidence for an appreciable $J^P = 1/2^-$ component in low mass N → Nπ diffractive dissociation. This is in violation of the Gribov-Morrison rule which would allow only $1/2^+$, $3/2^-$, $5/2^+$, etc. The reactions $\pi^\pm p \to \pi^\pm(p\pi^0)$ and $\pi^\pm(n\pi^+)$ have been analyzed by OCHS 75 at 14 GeV/c and OTTER 77 at 16 GeV/c [who included data on $\pi^\pm p \to \pi^0(p\pi^\pm)$]. In each case the data were fitted with coherent sums of diffractive and Δ-production amplitudes. Both analyses concluded that there is significant diffractive production of $1/2^-$ background for πN masses below 1.3 - 1.4 GeV. Moreover, the diffractively produced πN system could be described completely by $1/2^-$ and $3/2^+$ waves only (i.e., both Gribov-Morrison violating), although a sizeable $3/2^-$ contribution could not be excluded. SOTIRIOU 75 also analyzed $\pi^+p \to \pi^+(n\pi^+)$ at 16 GeV/c for $n\pi^+$ masses below 2 GeV. In addition to enhancements associated with known resonances, a 200-MeV broad bump at 1.35 GeV was found. The J^P determination at low mass was not completely unambiguous, but the bump appears to be predominantly $1/2^-$ below 1.35 GeV, and predominantly $1/2^+$ above. RUSHBROOKE 76 analyzed data on $np \to (p\pi^-)p$ from 9 to 24 GeV/c. They used a Deck-plus-resonances parametrization and found broad resonance signals in both the $1/2^-$ and $1/2^+$ waves at about 1.4 GeV, as well as a large $1/2^-$ Deck contribution peaking below 1.3 GeV. In STRACHMAN 75 the t-channel isospin-0 and isospin-1 parts of $\bar{N}N \to \bar{N}(N\pi)$ at 5.7 GeV/c were separated and the $I_t = 1$ Nπ mass spectrum found to contain known resonance peaks, while the $I_t = 0$

spectrum had only a broad bump centered at 1.35 GeV.

The low mass $\pi\pi N$ system exhibits a broad enhancement below 2 GeV on which subsidiary peaks are superimposed at around 1.5 and 1.7 GeV. The production characteristics are consistent with diffraction.

Partial-wave analyses of diffractively produced $\pi\pi N$ systems have recently been carried out by CARNEY 76, BACON 77, HEINEN 77, IDSCHOK 78, and OTTER 78. All these analyses use bubble chamber data in the medium energy range. CARNEY 76 use a compilation of data on $K^+p \to K^+(p\pi^+\pi^-)$ between 7.3 and 16 GeV/c. The reaction $K^-p \to K^-(p\pi^+\pi^-)$ is studied by HEINEN 77 at 4.2 GeV/c and by OTTER 78 at 10, 14.3, and 16 GeV/c. BACON 77 analyze the 10 and 16 GeV/c data of OTTER 78 together with $\pi^\pm p \to \pi^\pm(p\pi^+\pi^-)$ at 8, 16, and 23 GeV/c. IDSCHOK 78 study $pp \to p(p\pi^+\pi^-)$ at 12 and 24 GeV/c.

All the analyses agree that the low mass $\pi\pi N$ system can be adequately described assuming a dominant contribution from partial waves having spin-parities $J^P = 1/2^+$, $3/2^-$, and $5/2^+$, and having $\Delta\pi$, $p\varepsilon$, and, to a less extent, $p\rho$ decay modes only. CARNEY 76 require $J \geqslant 7/2$ above about 1.7 GeV. BACON 77 cannot rule out alternative solutions completely in terms of partial waves in the series $J^P = 1/2^-$, $3/2^+$, $5/2^-$, etc., although this conclusion is not supported by CARNEY 76. OTTER 78 find evidence for a small contribution (of order 20%) from $5/2^-(\ell=2)\Delta\pi$ in the mass region 1.60 - 1.75 GeV in addition to partial waves satisfying the Gribov-Morrison rule. The shape of the $5/2^-$ enhancement is consistent with a Breit-Wigner form ($M = 1.67$ GeV, $\Gamma = 0.15$ GeV) and is interpreted as evidence for production of $D'_{15}(1670)$.

It seems clear that the enhancement at 1.5 GeV is predominantly $3/2^-(\ell=0)\Delta\pi$, although other partial waves such as $1/2^+(\ell=0)p\varepsilon$ are contributing in this region. No evidence for a resonant nature of the 1.5 GeV enhancement could be obtained from studies of relative phases (BACON 77, HEINEN 77, IDSCHOK 78, and OTTER 78).

The situation concerning the peak at 1.7 GeV is more complex in that the different analyses come to different conclusions as to the detailed spin-parity decomposition. However, all analyses do agree that $5/2^+$ is not the only contribution, and thus the enhancement cannot be completely associated with the $F'_{15}(1688)$. CARNEY 76 are unable to conclusively identify all the waves contributing to the enhancement, but both $3/2^-(\ell=1)p\varepsilon$ and $3/2^-(\ell=2)\Delta\pi$ are strong. On the other hand, BACON 77 find that $1/2^+(\ell=0)p\varepsilon$ is important in the 1.7 GeV region, together with $3/2^-(\ell=1)p\varepsilon$, $3/2^-(\ell=2)\Delta\pi$, and $5/2^+(\ell=1)\Delta\pi$. HEINEN 77 also find that spin-parity $1/2^+$ contributes, but that the decay mode is $(\ell=1)\Delta\pi$. In addition, $3/2^-(\ell=1)p\varepsilon$ and $5/2^+(\ell=2)p\varepsilon$ are present. Spin-parity $5/2^+$ is the most important contribution to the data of IDSCHOK 78 above 1.6 GeV, but $3/2^-(\ell=1)p\varepsilon$ is also significant. No partial wave exhibits a phase variation. OTTER 78 also conclude that the 1.7 GeV enhancement is composed of several partial waves with spin-parities $1/2^+$ (or $1/2^-$ — the analysis cannot distinguish the two possibilities in this region), $3/2^-$, and $5/2^+$ all contributing, as well as $5/2^-(\ell=2)\Delta\pi$.

The production of the different spin-parity states depends very differently on four-momentum transfer (IDSCHOK 78). Thus the apparent disagreement concerning the exact nature of the 1.7 GeV enhancement could be due in part to the different regions of four-momentum transfer used by the various analyses.

It is interesting to note that the Gribov-Morrison rule appears to be reasonably well satisfied for diffractively produced $\pi\pi N$ systems, in contrast to the situation for πN diffraction dissociation. This could be connected with the fact that the Deck mechanism is expected to be important at low mass and that the major contribution is to S-wave states. Thus S-wave $\Delta\pi(J^P = 3/2^-)$ and $p\varepsilon(1/2^+)$ both give rise to spin-parities in the "allowed" series, whereas S-wave $\pi N(1/2^-)$ does not. A similar situation occurs in three-meson diffractive production, where the "allowed" series is dominant.

<u>References for Section V</u>

See the Data Card Listings.

Baryons

N's and Δ's, p, n, N(1470)

STATUS OF N* RESONANCES

THOSE WITH AN OVERALL STATUS OF *** OR **** ARE INCLUDED IN THE MAIN BARYON TABLE. THE OTHERS AWAIT CONFIRMATION.

STATUS AS SEEN IN --

PARTICLE	LIJ	OVERALL STATUS	TOTAL≠ CR.S.	PI N	ETA N	K LAM	K SIG	PI DE	GAM N	OTHER CHANN.
N(939)	P11	****								
N(1470)	P11	****		****	*			***	***	EPS N
N(1520)	D13	****	****	****	*			***	***	RHO N
N(1535)	S11	****		****	****			*	***	RHO N
N(1540)	P13	*						*		RHO N
N(1650)	S11	****		****	*	***	**	***	***	RHO N
N(1670)	D15	****	***	****	*	*		***	***	RHO N
N(1688)	F15	****	***	****				***	***	RHO N
N(1700)	D13	****		***	*	**	*	**	**	RHO N
N(1710)	P11	****		****	*	**	*	***	**	RHO N
N(1810)	P13	****		****	*	**	*	*	*	RHO N
N(1990)	F17	***		***	*	*	*		*	
N(2000)	F15	**		**	*	*	*			
N(2040)	D13	**		**	*	*			*	
N(2100)	S11	*		*						
N(2100)	D15	**		**	*	*				
N(2190)	G17	****	***	****	*	*	*		*	
N(2200)	G19	****		****	*					
N(2220)	H19	****	***	****	*					
N(2600)	I111	***		***						
N(2700)	K113	*		*						
N(2800)	G19	*		*						
N(3030)		***	***	*						
N(3245)		*	*							
N(3690)		*	*							
N(3755)		*	*							
DEL(1232)	P33	****	****	****	F				****	
DEL(1550)	P31	**			O			*		RHO N
DEL(1650)	S31	****	**	****	R			***	**	RHO N
DEL(1670)	D33	****	***	****	B		*	***	***	RHO N
DEL(1690)	P33	***		***	I			***	*	RHO N
DEL(1890)	F35	****	*	****	D		*	**	**	RHO N
DEL(1900)	S31	**	*	**		D	*			
DEL(1910)	P31	****	*	****		E	*	*	*	RHO N
DEL(1950)	F37	****	***	****		N	*	**	***	RHO N
DEL(1960)	P33	**		**	F		*			
DEL(1960)	D35	***	*	***	O		*	*	*	
DEL(2160)		***		***	R		*			
DEL(2300)	H39	*		*	B					
DEL(2420)	H311	***	***	***	I				*	
DEL(2500)	G39	*		*	D					
DEL(2750)	I313	*		**		D				
DEL(2850)		***	***	**		E				
DEL(2950)	K315	*		**		N				
DEL(3230)		***	***	*						

**** GOOD, CLEAR, AND UNMISTAKABLE.
*** GOOD, BUT IN NEED OF CLARIFICATION OR NOT ABSOLUTELY CERTAIN.
** NEEDS CONFIRMATION.
* WEAK.
≠ ATTRIBUTED TO THE STATE CLOSEST TO WHERE THE CROSS SECTION PEAKS.

S=0 I=1/2 NUCLEON STATES (N)

p

16 PROTON(938, J=1/2) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

n

17 NEUTRON(939, J=1/2) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

N(1470) P'_{11}

61 N*1/2(1470, JP=1/2+) I=1/2

MASS AND WIDTH ARE BEST DETERMINED FROM PARTIAL WAVE ANALYSES. WE LIST PRODUCTION EXPERIMENTS SEPARATELY -- SEE BELOW.

AYED 76 CLAIMS TWO P11 STATES IN THE 1500 MEV REGION. WE TENTATIVELY LIST BOTH HERE.

61 N*1/2(1470) MASS (MEV)

```
M        (1370.0)                   BRANDSEN  65 RVUE   PHASE-SHIFT ANAL  9/66
M        (1380.0)                   ROPER     65 RVUE   PHASE-SHIFT ANAL  9/66
M   1    (1470.0)                   BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
M   1         WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M   3    (1466.0)                   DONNACH1  68 RVUE   PHASE-SHIFT ANAL  6/68
M   6    (1461.0)                   AYED      70 IPWA                     1/71
M   6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   4    (1462.0)                   DAVIES    70 RVUE   P-S ANAL  SOL A   8/69
M   7    (1470.)                    ALMEHED   72 IPWA                     2/72
M         1405. TO 1420.            CRAWFORD  75 DPWA   PI N PHOTO-PROD   1/76
M    L    1415. OR 1390.            LONGACRE  75 IPWA   PI N TO 2PI N    11/75
M    L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M   2     (1413.)                   AYED      76 IPWA                    11/77
M   2     (1532.)                   AYED      76 IPWA                    11/77
M   2   AYED 76 FINDS 2 DIFFERENT P11 RESONANCES IN THIS REGION IN CONTRAST 11/77
M   2   TO ALL OTHER PWAS.  WE LIST BOTH TOGETHER HERE UNTIL             11/77
M   2   SITUATION IS FURTHER CLARIFIED.                                  11/77
M         (1404.)                   BARBOUR   76 DPWA    PI N PHOTO-PROD  1/76
M         (1460.)                   BERENDS   77 IPWA    PI-N PHOTO-PROD  1/78
M   8     (1380.)                   LONGACRE  77 IPWA    PI N TO 2PI N   11/77
M   8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M   8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                      11/77
M    9    (1417.)                   BARBOUR   78 DPWA    PI-N PHOTO-PROD  3/79*
M    9  SUPERSEDES BARBOUR 76.                                            3/79*
M   5     (1472.)                   BAKER     79 DPWA  0 PI- P TO ETA N  12/79*
M          1450.       30.          CUTKOSKY  79 IPWA    PI N TO PI N    12/79*
M          1410.       12.          HOEHLER   79 IPWA    PI N TO PI N    12/79*
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)
```

61 N*1/2(1470) WIDTH (MEV)

```
W   1      (255.0)                  BAREYRE   68 RVUE                    11/67
W   3      (211.0)                  DONNACH1  68 RVUE                     6/68
W   6      (164.0)                  AYED      70 IPWA                     1/71
W   4      (391.)                   DAVIES    70 RVUE    P-S ANAL  SOL A  8/69
W   7      (220.)                   ALMEHED   72 IPWA                     2/72
W           255. TO  396.           CRAWFORD  75 DPWA    PI N PHOTO-PROD  1/76
W    L      180. OR  200.           LONGACRE  75 IPWA    PI N TO 2PI N   11/75
W   2      (182.)   (SMALLER MASS)  AYED      76 IPWA                    11/77
W   2       (75.)   (LARGER MASS)   AYED      76 IPWA                    11/77
W          (330.)                   BARBOUR   76 DPWA    PI N PHOTO-PROD  1/76
W          (279.)                   BERENDS   77 IPWA    PI-N PHOTO-PROD  1/78
W   8      (200.)                   LONGACRE  77 IPWA    PI N TO 2PI N   11/77
W    9     (331.)                   BARBOUR   78 DPWA    PI-N PHOTO-PROD  3/79*
W   5      (113.)                   BAKER     79 DPWA  0 PI- P TO ETA N  12/79*
W           370.       80.          CUTKOSKY  79 IPWA    PI N TO PI N    12/79*
W           135.       10.          HOEHLER   79 IPWA    PI N TO PI N    12/79*
W          . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
```

61 N*1/2(1470) REAL PART OF POLE POSITION (MEV) 1/74

```
RE        (1375.)     (5.)          LEE       73         FIT TO ALMEHED72  1/74
RE        (1381.)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE   8     1360. OR 1333.           LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE        (1369.)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
```

61 N*1/2(1470) -2*IMAG PART OF PCLE POSITION (MEV) 1/74

```
IM        (216.)     (10.)          LEE       73         FIT TO ALMEHED72  1/74
IM        (209.)                    LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   8     167. OR 234.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM        (178.)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
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61 N*1/2(1470) REAL PART OF ELASTIC POLE RESIDUE (MEV)

```
RER        (-9.)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
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61 N*1/2(1470) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

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IMR       (-48.)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
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61 N*1/2(1470) ABSOLUTE VALUE OF POLE RESIDUE (MEV) 1/74

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ABS        (74.)      (5.)          LEE       73         FIT TO ALMEHED72  1/74
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61 N*1/2(1470) PHASE OF POLE RESIDUE (RADIANS) 1/74

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PH         (-1.4)                   LEE       73         FIT TO ALMEHED72  1/74
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61 N*1/2(1470) PARTIAL DECAY MODES

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                                                     DECAY MASSES
P1    N*1/2(1470) INTO PI N                          139+ 938
P2    N*1/2(1470) INTO N EPSILON                     938+1300
P3    N*1/2(1470) INTO N*3/2(1232) PI               1232+ 139
P4    N*1/2(1470) INTO N PI PI                       938+ 139+ 139
P5    N*1/2(1470) INTO GAMMA N                         0+ 938
P6    N*1/2(1470) INTO N RHO                         938+ 776
P7    N*1/2(1470) INTO GAM P, HELICITY=1/2             0+ 938
P8    N*1/2(1470) INTO GAM N, HELICITY=1/2             0+ 939
P9    N*1/2(1470) INTO ETA N                         939+ 548
P10   N*1/2(1470) INTO K LAMBDA                      497+1115
P11   N*1/2(1470) INTO N RHO,S=1/2,P-WAVE            938+ 776
P12   N*1/2(1470) INTO N RHO,S=3/2,P-WAVE            938+ 776
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61 N*1/2(1470) BRANCHING RATIOS

```
R1        N*1/2(1470) INTO (PI N)/TOTAL                              (P1)
R1  1          (0.68)                BAREYRE   68 RVUE                    11/67
R1  3          (0.658)               DONNACH1  68 RVUE                     6/68
R1  6          (0.564)               AYED      70 IPWA                     1/71
R1  4          (0.49)                DAVIES    70 RVUE    P-S ANAL  SOL A  8/69
R1  A          (0.67)    (0.18)      SAXON     70 HBC     AT 1400 MEV      6/70
R1  B          (0.58)    (0.09)      SAXON     70 HBC                      6/70
R1  7          (0.65)                ALMEHED   72 IPWA                     2/72
R1  2          (.54) (SMALLER MASS)  AYED      76 IPWA                    11/77
R1  2          (.16) (LARGER MASS)   AYED      76 IPWA                    11/77
R1  A A AND B CORRESPOND TO THE 2 BEST SOLUTIONS.  ANALYSIS IS DONE ON THRE
R1  B BODY DECAYS, ASSUMING ONLY P1, P2 AND P3 DECAYS PRESENT.
R1              .65       .05        CUTKOSKY  79 IPWA    PI N TO PI N    12/79*
R1              .51       .05        HOEHLER   79 IPWA    PI N TO PI N    12/79*
R1             . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 2.0)
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
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Data Card Listings

For notation, see key at front of Listings.

Baryons
N(1470)

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R2      N*1/2(1470) INTO (N EPSILON)/TOTAL                   (P2)
R2           DOMINANT INELASTIC DECAY   THURNAUER 65 RVUE -                      11/67
R2           DOMINANT INELASTIC DECAY   NAMYSLOWS 66 RVUE -                      11/67
R2           DOMINANT INELASTIC DECAY   ROSENFELD 67 RVUE -                      11/67
R2           DCMINANT INELASTIC DECAY   MORGAN    68 RVUE    ISOBAR MODEL         6/68
R2  D          (0.16)                   DIEM      70 IPWA    3 BODY ANALYSIS      1/71
R2  D        ASSUMING  R1= 0.61
R2  A          (0.30)   (0.20)          SAXCN     70 HBC                          6/70
R2  B          (0.20)   (0.12)          SAXON     70 HBC                          6/70
R2  A AND B CORRESPOND TO THE 2 BEST SOLUTIONS, SEE NOTE IN R1.

R3      N*1/2(1470) INTO (N*3/2(1232) PI)/TOTAL              (P3)
R3  D          (0.17)                   DIEM      70 IPWA    3 BODY ANALYSIS      1/71
R3  D        ASSUMING  R1= 0.61
R3  A          (0.03)   (0.20)          SAXON     70 HBC                          6/70
R3  B          (0.22)   (0.12)          SAXON     70 HBC                          6/70
R3  A AND B CORRESPOND TO THE 2 BEST SOLUTIONS, SEE NOTE IN R1.
R3  R          (0.20)                   MAKAROV   71 IPWA  0 PI- P TO PI PI N     3/72
R3  R   ASSUMES R1=0.6. MAXIMUM CM ENERGY ANALYZED WAS 1435 MEV.

R4      N*1/2(1470) INTO (GAMMA N)/(PI N)                    (P5)/(P1)
R4   F        STRONG INDICATION         ROSSI     73 DBC    0 GAM N TO PI-P     . 2/73
R4   F  DISAGREES WITH OTHER DATA                                                 2/73

R5      N*1/2(1470) INTO (N RHO )/TOTAL                      (P6)
R5  D          (0.07)                   DIEM      70 IPWA    3 BODY ANALYSIS      1/71
R5  D        ASSUMING  R1= 0.61

R6      N*1/2(1470) INTO (GAMMA N)/TOTAL                     (P5)
R6  E          (.0006)                  MICKENS   71         THEORETICAL EST. 10/71
R6  E   TOTAL WIDTH TAKEN AS 250 MEV.

R7      N*1/2(1470) FROM PI N INTO ETA N                     SQRT(P1*P9)          2/74
R7             (+.23)                   LEMOIGNE  73 DPWA    1488 TO 1685 MEV     2/74
R7  9          (+.328)                  FELTESSE  75 DPWA  0 1488 TO 1745 MEV 11/75
R7  9   SUPERSEDES LEMOIGNE 73, USES M AND W OF AYED 76 (LARGER MASS).           11/75
R7  9   AN ALTERNATIVE WHICH CAN NOT BE DISTINGUISHED FROM THIS IS TO HAVE      11/75
R7  9   A P13 RESONANCE WITH M=1530, W=79, AND COUPLING=+.271                   11/75
R7  5   BAKER 79 FINDS A COUPLING OF THE N*(1470) TO THE ETA N CHANNEL         12/79*
R7  5   NEAR (BUT SLIGHTLY BELOW) THRESHOLD.                                    12/79*

R8      N*1/2(1470) FROM PI N TO K LAMBDA                    SQRT(P1*P10)         4/75
R8 C          -.296      .068           DEVENISH  74        0 FIXED T DISP REL   4/75
R8 C    EXTRAPOLATION OF PARAMETRIZED AMPLITUDE BELOW THRESHOLD.                 4/75

R9      N*1/2(1470) FROM PI N TO N*3/2(1232) PI              SQRT(P1*P3)         11/75
R9   L         (-.30)OR  -.37           LONGACRE  75 IPWA    PI N TO 2PI N       11/75
R9  8          (-.41)                   LONGACRE  77 IPWA    PI N TO 2PI N       11/77
R9  8   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R10     N*1/2(1470) FROM PI N TO N RHO,S=1/2,P-WAVE          SQRT(P1*P11)        11/75
R10  L         (0.0) OR  -.23           LONGACRE  75 IPWA    PI N TO 2PI N       11/75
R10 8          (+.11)                   LONGACRE  77 IPWA    PI N TO 2PI N       11/77

R11     N*1/2(1470) FROM PI N TO N RHO,S=3/2,P-WAVE          SQRT(P1*P12)        11/77
R11 8          (-.18)                   LONGACRE  77 IPWA    PI N TO 2PI N       11/77
R11 8   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R12     N*1/2(1470) FROM PI N TO N EPSILON                   SQRT(P1*P2)         11/75
R12  L         (.18)OR  +.23            LONGACRE  75 IPWA    PI N TO 2PI N       11/75
R12 8          (+.18)                   LONGACRE  77 IPWA    PI N TO 2PI N       11/77

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                     61  N*1/2(1470) PHOTON DECAY AMPL(GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*1/2(1470) INTO GAM P, HELICITY=1/2 (GEV**-1/2)
A1            -.096      .022           DEVENISH  73 DPWA    PI N PHOTO PROD      2/74
A1           (-.080)                    HEMMI1    73       + FWD PIO PHTOPROD     2/74
A1            -.055      .028           MOORHOUS  73 DPWA    PI N PHOTO-PROD      2/73
A1            -.079      .012           DEVENIS2  74 DPWA    PI N PHOTO-PROD      4/75
A1            -.066      .013           KNIES     74 DPWA    PI N PHOTO PROD      2/74
A1            -.070      .023           METCALF   74 DPWA    PI N PHOTO-PROD      2/74
A1            -.087      .002           MOORHOUS  74 DPWA    PI N PHOTO-PROD      2/74
A1            -.070      .040           CRAWFORD  75 DPWA    PI N PHOTO-PROD      1/76
A1           (-.071)                    KRIVETS   75 DPWA    PI-N PHOTO-PROD      1/78
A1           (-.053)                    BARBOUR   76 DPWA    PI N PHOTO-PROD      1/76
A1            -.087      .006           FELLER    76 DPWA    PI N PHOTO-PROD      2/77
A1            -.038      .013           AZNAURYAN 77 DPWA    PIO PHTPRO,SOL 1 12/79*
A1            -.019      .011           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79*
A1           (-.076)                    BERENDS   77 IPWA    PI-N PHOTO-PROD      1/78
A1   9        -.075      .015           BARBOUR   78 DPWA    PI-N PHOTO-PROD      3/79*
A1   N       (-.125)                    NOELLE    78         PI-N PHOTO-PROD      1/80*
A1   N  CONVERTED TO OUR CONVENTIONS USING M=1.486, W=.613 FROM NOELLE 78.       1/80*
A1          . . . . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 3.0)

A2      N*1/2(1470) INTO GAM N, HELICITY=1/2 (GEV**-1/2)
A2              .089     .056           DEVENISH  73 DPWA    PI N PHOTO PROD      2/74
A2 8         (-.001)                    HEMMI2    73        0 GAM N TO PIO N      4/75
A2 8    CONVERTED TO OUR CONVENTIONS USING M AND W FROM WALKER69 AND X=.55       4/75
A2             +.002     .025           MOORHOUS  73 DPWA    PI N PHOTO-PROD      2/73
A2 F            .117     .011           ROSSI     73 DPWA  0 GAM N TO PI- P       4/75
A2 F    CONVERTED TO OUR CONVENTIONS USING M AND W FRCM ROSSI73 AND X=.55        4/75
A2 5          (.083)                    BENEVENT  74 DPWA  0 GAM N TO PI- P       4/75
A2 5    CONVERTED TO OUR CONVENTIONS USING M=1470 MEV, W=230 MEV, X=.55          4/75
A2              .041     .025           DEVENIS2  74 DPWA    PI N PHOTO-PROD      4/75
A2              .000     .013           KNIES     74 DPWA    PI N PHOTO PROD      2/74
A2              .043     .035           METCALF   74 DPWA    PI N PHOTO-PROD      2/74
A2              .033     .013           MOORHOUS  74 DPWA    PI N PHOTO-PROD      2/74
A2             +.044     .007           CRAWFORD  75 DPWA    PI N PHOTO-PROD      1/76
A2           (+.058)                    BARBOUR   76 DPWA    PI N PHOTO-PROD      1/76
A2   9         +.059     .016           BARBOUR   78 DPWA    PI-N PHOTO-PROD      3/79*
A2   N        (.062)                    NOELLE    78         PI-N PHOTO-PROD      1/80*
A2   N  CCNVERTED TO OUR CONVENTIONS USING M=1.486, W=.613 FROM NOELLE 78.       1/80*
A2          . . . . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 2.9)

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REFERENCES FOR N*1/2(1470)


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BRANDSEN 65 PR 139 B1566        +ODONNELL, MOORHOUSE            (DURHAM, RHEL)IJP
ROPER    65 PR 138 B190         LD ROPER,RM WRIGHT,BT FELD      (LRL-LVMR,MIT)IJP
THURNAUE 65 PRL 14 985          P G THURNAUER                            (ROCH)

NAMYSLOW 66 PR 157 1328         NAMYSLOWSKI,RAZMI,ROBERTS  (STAN,EDIN,LOIC)

ROSENFEL 67 IRVINE CONF         A H ROSENFELD, P SODING                   (LRL)

BAREYRE  68 PR 165 1731         P BAREYRE, C BRICMAN, G VILLET     (SACLAY)IJP
DCNNACH1 68 PL 26B 161          A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139          DONNACHIE  RAPPORTEUR.S TALK            (GLAS)
    ALSO 68 THESIS              R G KIRSOPP                             (EDIN)
MORGAN   68 PR 166 1731         D MORGAN                                (RHEL)

AYED     70 KIEV CONF           R AYED,P BAREYRE, G VILLET           (SACL)IJP
DAVIES   70 NP B21 359          A DAVIES                                (GLAS)
DIEM     70 KIEV CONF.          + SMADJA, CHAVANON, DELER, DOLBEAU+  (SACL)
SAXON    70 PR D2 1790          SAXON, MULVEY, CHINOWSKY            (OXF,LRL)

MAKAROV  71 SJNP 13 510         ,GASILOVA,NELYUBIN,++          (IOFFE INST)IJP
MICKENS  71 LNC  1  707         R E MICKENS                             (FISK)
ALMEHED  72 NP B40 157          +LOVELACE                         (LUND,RUTG)IJP

DEVENISH 73 PL 47B 53           DEVENISH,RANKIN,LYTH         (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79           HEMMI,INAGAKI+          (KYOTO+SAGA+KEK+TCKY)IJP
HEMMI2   73 NP B55 333          +INAGAKI,KIKUCHI,MAKI,MIYAKE+ (KYOTO,TOKYO)IJP
LEE      73 PRL 31 1029         LEE,SHAW          (UCI+ROYAL HOLLOWAY COLLEGE)IJP
LEMOIGNE 73 PURDUE CONF. 93     +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOUS 73 PL 43B 44           MOORHOUSE, OBERLACK               (GLAS+LBL)IJP
ROSSI    73 NC 13A 59           +PIAZZA,SUSINNO,+      (ROMA,FRAS,NAPL,PAVIA)IJP
    ALSO 71 LNC 2 1183          CARBONARA,FIORE,+      (NAPL,FRAS,PAVIA,ROMA)IJP

BENEVENT 74 NC 19A 529          BENEVENTANO,DANGELO,NOTARISTEFANI,+  (RCMA)IJP
DEVENISH 74 NP B81 330          DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LCUC)
DEVENIS2 74 PL 52B 227          DEVENISH,LYTH,RANKIN          (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680          KNIES,MOORHOUSE,OBERLACK             (LBL,GLAS)IJP
METCALF  74 NP B76 253          W J METCALF,R L WALKER                    (CIT)IJP
MOCRHOUS 74 PRD 9 1             MOORHOUSE,OBERLACK,ROSENFELD     (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125          R L CRAWFORD                             (GLAS)IJP
FELTESSE 75 NP B93 242          +AYED,BAREYRE,BORGEAUD,CAVID,ERNWEIN+(SACL)IJP
KRIVETS  75 SJNP 20 430         +MIROSHNICHENKO,NIKIFOROV,SANIN+         (KIEV)IJP
    ALSO 74 SJNP 19 112         KRIVETS,NIKIFOROV,SANIN,SHALATSKII   (KIEV)IJP
LONGACRE 75 PL 55B 415          +ROSENFELD,LASINSKI,SMADJA+          (LBL,SLAC)IJP
    ALSO 78 PRD 17 1795         LONGACRE,LASINSKI,ROSENFELD+         (LBL,SLAC)

AYED     76 CEA-N-1921          AYED (THESIS)                            (SACL)IJP
BARBOUR  76 NP B111 358         I. M. BARBOUR,R. L. CRAWFORD             (GLAS)IJP
FELLER   76 NP B104 219         +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP

AZNAURYA 77  EFI-264(57)-77     +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
BERENDS  77 NP B136 317         F.A.BERENDS,A.DONNACHIE              (LEID,MCHS)IJP
LONGACRE 77 NP B122 493         LONGACRE,DOLBEAU                          (SACL)IJP
    ALSO 76 NP B108 365         DOLBEAU,TRIANTIS,NEVEU,CADIET             (SACL)IJP

BARBOUR  78 NP B141 253         BARBOUR,CRAWFORD,PARSONS                 (GLAS)
NOELLE   78 PTP 60 778          P. NOELLE                                (NAGO)
BAKER    79 NP B156 93          +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+   (RHEL)IJP
CUTKOSKY 79 PRD 20 2839         +FORSYTH,HENDRICK,KELLY              (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN            /KARLSRUHE IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS

BAREYRE  64 PL 8 137            +BRICMAN,VALLADAS,VILLET, +   (SACLAY,CAEN) IJ
BAREYRE  65 PL 18 342           +BRICMAN, STIRLING, VILLET         (SACLAY)IJP
DALITZ   65 PL 14 159           R H DALITZ, R G MOORHOUSE           (OXF,RHEL)
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                                (LRL)
DCNNACHI 69 NP 10B 433          A DONNACHIE, R KIRSOPP             (GLAS+EDIN)
WALKER   69 PR 182 1729         R L WALKER                               (CIT)IJP
AYED     70 PL 31B 598          +BAREYRE,VILLET                       (SACLAY)
BERARDO  70 PRL 24 419          +HADDOCK,NEFKENS,..,PARSONS+..     (UCLA+LRL)
AYED     72 BATAVIA CONF        R AYED,P BAREYRE, Y LEMOIGNE             (SACL)

      THE FOLLOWING ARE THEORETICAL PAPERS CONCERNING THE N*1/2(1470) --
RESNICK  66 PR 150 1292         L RESNICK                          (NIELS BOHR)
SCHWARZ  66 PR 152 1325         J H SCHWARZ                               (LRL)
BALL     67 PR 155 1725         JS BALL, GL SHAW, DY WONG     (UCLA,UCI,UCSD)
GOLDBERG 67 PR 154 1558         H GOLDBERG                            (CORNELL)
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1470 MEV REGION - PRODUCTION EXPERIMENTS

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                    91  N*1/2(1470, JP=    ) I=1/2   PRODUCTION EXPERIMENTS

                    UNDER THIS HEADING WE INCLUDE ALL BUMPS WHICH LIE WELL
                    BELOW 1500 MEV.  SEE THE MINI-REVIEW PRECEDING THE N
                    AND DELTA LISTINGS FOR A DISCUSSION OF PRODUCTION
                    EXPERIMENTS.

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                    91  N*1/2(1470) MASS (MEV) (PROD.EXP.)

M          (1400.)   APPROX               COCCONI   64 CNTR +  PP 3.6-12 GEV/C
M          (1425.)   APPROX               ADELMAN   65 HBC  +  K-P 1.45 GEV/C     7/66
M          (1430.)   APPROX               ANKENBRAN 65 CNTR +  PP 7.1 GEV/C       7/66
M          (1400.)   APPROX               BELLETTIN 65 SPRK +  PP,D 10-26 GEV/C   7/66
M          (1405.)    (15.)               ANDERSON  66 SPRK +  PP, 6-30 GEV/C     7/66
M          (1410.)    (15.)               BLAIR     66 CNTR +  PP 2.8-7.9 GEV/C   7/66
M          (1400.)    (30.)               FOLEY     67 CNTR    PI+- P AND PP     11/67
M          (1450.)    (17.)               ALMEIDA   68 HBC  +  PP-P2PI ,10GEV/C 10/69
M          (1420.)   APPROX               BELL      68 HBC     PI+- P, 6 GEV/C    6/68
M          (1400.)   APPROX               LAMSA     68 HBC     PI-P , 8 GEV/C     6/68
M    S  175(1446.)    (11.)               SHAPIRA   68 DBC     INTO PPI,PN 7.0  10/69
M    S   THE EFFECT OF SHAPIRA 68, WITH MUCH IMPROVED DATA, HAS ALMOST          11/77
M    S   DISAPPEARED (YEKUTIEL1 72).                                            11/77
M          (1390.)    (20.)               TAN       68 HBC     PP TO PIP, 6.1   10/69
M       120(1443.)    (15.)               RHODE     69 HBC     PP 22 GEV/C      10/69
M          (1410.)    (13.)               ANDERSON  70 MMS  -  PI- P TO PI- MMS  2/71
M          (1430.)    (20.)               BALLAM    71 HBC  +- PI+-P AT 16GEV    2/72
M          (1460.)                        BEKETOV   71 HBC  +  PI- P 4.45GEV/C   3/72
M          (1461.)    (10.)               BOESEBEC  71 RVUE    PP,PI-P,K-P PROD  3/72
M       120(1462.0)    (6.0)    120/80    MA        71 HBC  +  P P TO P N PI    10/71
M          (1425.)    (25.)               RUSHBROOKE71 HBC  +  PP TO P2PI 16GEV  2/72
M          (1411.0)   (10.0)              EDELSTEIN 72 MMS  +  PP 6 TO 30 GEV    1/73
M        64(1410.0)   (33.0)              GAGE      72        0 PD  5.9GEV/C    12/72
M          (1464.0)    (7.0)     45/45    KARSHON   72 DBC  +  PD--PD2PI 7 GEV  12/72
M          (1250.)                        LISSAUER  72 DBC   0 K+N TO K+N* 12GV  1/78
M          (1440.)    (15.)               RONAT     72  HBC    PI+P TO 3PI P     2/73
M          (1479.)     (8.)               LICHTMAN  74 HBC  +  PI+P TO 3PI P     4/75
M          (1430.)     (8.)               LICHTMAN  74 HBC  +  PI-P TO 3PI P     4/75
M    1     (1450.)                        BLOBEL    75 HBC  +  PP TO P(PI+PI-P)  1/76
M    1   PWA INDICATES PI+PI-P ENHANCEMENT IS PRIMARILY AN                       1/76
M    1   S-WAVE DELTA++PI- SYSTEM WITH I,JP=1/2,3/2-.                            1/76
M          (1450.)    (16.)               CAVALLI   75 SPEC +  PP TO 2N*,W=23GV  1/76
M          (1462.)    (11.)               CAVALLI   75 SPEC +  PP TO 2N*,W=31GV  1/76
M          (1466.)    (28.)               CAVALLI   75 SPEC +  PP TO 2N*,W=53GV  1/76
M          (1390.)    (10.)               MUSGRAVE  75 HBC     K+ P TO K PI N   11/75
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Baryons
N(1470), N(1520)

Data Card Listings
For notation, see key at front of Listings.

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M           1350. TO 1400.              STRACHMA  75  BC      NBAR (N PI)       1/76
M          (1450.)    (10.)             ATHERTON  76 HBC      PBAR P 5.7 GEV    2/77
M           1400. TO 1420.              RUSHBROO  76  HBC     P PI- S1-WAVE     2/77
M           1400. TO 1425.              RUSHBROO  76  HBC     P PI- P1-WAVE     2/77
M          (1458.)    (20.)             APPLE     77 SPEC +   P P TO P (P PIO)  1/78
M          (1473.)     (5.)             APPLE     77 SPEC +   P P TO P (N PI+)  1/78
M          (1460.)    (10.)             HEINEN    77 HBC  +   K-P TO K- N*+     1/78
M          (1470.)    (10.)             HEINEN    77 HBC    0 K-P TO KOBAR N*0  1/78
M  I       (1350.)                      CHADWICK  78 HYBR +   PI+-P  14 GEV/C   1/78
M  I    CHADWICK 78 CONCLUDE THAT AN INTERPRETATION OF THEIR PEAK AS A          1/78
M  I    RESONANCE IS HIGHLY IMPROBABLE.                                         1/78
M          (1490.)    (20.)             EKELOF    78 SPEC +   P HE--P PI PI HE  1/78
M  W   707(1454.)     (20.)             KENNEDY   78 HBC  +   PI+ P 10.3 GEV/C  3/79*
M  W    WIDTH FIXED AT 180 MEV.
M   G  870(1419.)      (7.)             APELDOORN 79 HBC  +-  PBAR P 7.2 GEV/C 12/79*
M   G  PEAK COULD NOT BE FITTED WITH SINGLE BREIT-WIGNER.  GAUSSIAN OF         12/79*
M   G  SIGMA 51 MEV FOLDED IN.                                                 12/79*
M          (1360.)                      HIROSE    79 HBC  +   PI+P 16 GEV/C    12/79*

M   B      (1250.)                      BERLAND   74 HBC  +0 ISOSPIN ANALYSIS 10/74
M   B      (1230.)                      BRAUN2    75  BC      PBAR P AND D,5.7 11/75
M   B      (1230.)                      STRACHMA  75  BC      NBAR (N PI)       1/76
M   B   THE EFFECT SEEN BY BERLAND 74 IN A PRISM PLOT ANALYSIS, BY BRAUN2       1/76
M   B   75 IN A DALITZ PLOT FIT, AND BY STRACHMAN 75 IN AN AMPLITUDE            1/76
M   B   ANALYSIS LIES WELL BELOW THE MASS OF MOST OTHER BUMPS LISTED HERE.      1/76
M   B   BRAUN2 75 AND STRACHMAN 75 ANALYSE THE SAME DATA.  BERLAND 74           1/78
M   B   CAN EXPLAIN THE OBSERVED FEATURES OF THEIR DATA WITH A DOUBLE           1/78
M   B   REGGE EXCHANGE MODEL.                                                   1/78
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91 N*1/2(1470) WIDTH (MEV) (PROD. EXP.)

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W          (100.)                       BELL      68 HBC      PI+- P AND PP     6/68
W   S  175 (198.)     (40.)             SHAPIRA   68 DBC                       10/69
W          (150.)     (60.)             TAN       68 HBC  +                    10/69
W      120 (100.)     (15.)             RHODE     69 HBC      PP 22 GEV/C      10/69
W          (210.)     (15.)             ANDERSON  70 MMS  -   PI- P TO PI- MMS  2/71
W          (150.)     (40.)             BALLAM    71 HBC  +-  PI+-P AT 16GEV    2/72
W          (100.)                       BEKETOV   71 HBC  +   P PI+ PI- MASS    3/72
W           (60.)     (20.)             BOESEBEC  71 RVUE     PP,PI-P,K-P PROD  3/72
W   T  120  (54.0)    (12.0)   120/80   MA        71 HBC  +   P P TO P N PI    .10/71
W   T   NARROW WIDTH SUGGESTS THIS IS NOT THE USUAL N*(1470).                  10/71
W          (125.)     (25.)             RUSHBROOKE71 HBC  +   PP TO P2PI 16GEV  2/72
W          (188.0)    (38.0)            EDELSTEIN 72 MMS  +   PP 6 TO 30 GEV    1/73
W          (212.0)    (62.0)            GAGE      72 DBC    0 PD  5.9GEV/C     12/72
W          (124.0)    (20.0)            KARSHON   72 DBC  +   PD--PD2PI 7 GEV  12/72
W          (300.)                       LISSAUER  72 DBC    0 K+N TO K+N* 12GV  1/78
W          (100.)     (30.)             RONAT     72  HBC     PI+P TO 3PI P     2/73
W           (50.)     (25.)             LICHTMAN  74 HBC  +   PI+P TO 3PI P     4/75
W           (62.)     (18.)             LICHTMAN  74 HBC  +   PI-P TO 3PI P     4/75
W          (250.)     (95.)             CAVALLI   75 SPEC +   PP TO 2N*,W=23GV  1/76
W          (249.)     (90.)             CAVALLI   75 SPEC +   PP TO 2N*,W=31GV  1/76
W          (205.)    (105.)             CAVALLI   75 SPEC +   PP TO 2N*,W=53GV  1/76
W          (145.)     (35.)             MUSGRAVE  75 HBC      K+ P TO K PI N   11/75
W          (145.)     (18.)             ATHERTON  76 HBC      PBAR P 5.7 GEV    2/77
W          (145.)     (30.)             RUSHBROO  76  HBC     P PI- S1-WAVE     2/77
W          (273.)     (90.)             RUSHBROO  76  HBC     P PI- P1-WAVE     2/77
W          (120.)     (20.)             APPLE     77 SPEC +   P P TO P (P PIO)  1/78
W           (30.)     (30.)             APPLE     77 SPEC +   P P TO P (N PI+)  1/78
W          (120.)     (20.)             HEINEN    77 HBC  +   K-P TO K- N*+     1/78
W           (90.)     (30.)             HEINEN    77 HBC    0 K-P TO KOBAR N*0  1/78
W          (200.)                       EKELOF    78 SPEC +   P HE--P PI PI HE  1/78
W   G  870 (120.)     (10.)             APELDOORN 79 HBC  +-  PBAR P 7.2 GEV/C 12/79*
W   G  PEAK COULD NOT BE FITTED WITH SINGLE BREIT-WIGNER.  GAUSSIAN OF         12/79*
W   G  SIGMA 51 MEV FOLDED IN.                                                 12/79*
W           (67.)                       HIROSE    79 HBC  +   PI+P 16 GEV/C    12/79*
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91 N*1/2(1470) PARTIAL DECAY MODES (PROD. EXP.)

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                                                          DECAY MASSES
P1      N*1/2(1470) INTO PI N                            139+ 938
P2      N*1/2(1470) INTO N PIPI(J,I=0)                   938+ 139+ 139
P3      N*1/2(1470) INTO N*3/2(1232) PI                 1232+ 139
P4      N*1/2(1470) INTO N PI PI                         938+ 139+ 139
P5      N*1/2(1470) INTO GAMMA N                           0+ 938
P6      N*1/2(1470) INTO N RHO                           938+ 776
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91 N*1/2(1470) BRANCHING RATIOS (PROD. EXP.)

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R1      N*1/2(1470) INTO (PI N)/TOTAL                       (P1)
R1           (.66)                      TAN       68 HBC      PP TO PIP, 6.1   10/69

R2      N*1/2(1470) INTO (N*3/2(1232) PI)/TCTAL             (P3)
R2              PROBABLY SEEN           JESPERSEN 68 HBC      PP 22 BEV/C      11/68
R2              PROBABLY SEEN           LAMSA     68 HBC      PI-P 8 BEV/C     11/68
R2              DOMINANT                BLOBEL    75 HBC  +   PP TO P(PI+PI-P)  1/78

R3      N*1/2(1470) INTO (N*3/2(1232) PI)/(N P PI)          (P3)/(P4)
R3 P          0.5       0.2             HEINEN    77 HBC  +   K-P TO K- N*+     1/78
R3 P     FOR THE P PI+ PI- FINAL STATE ONLY.                                    1/78
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REFERENCES FOR N*1/2(1470) (PRCD. EXP.)


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COCCONI   64 PL    8 134          +LILLETHUN,SCANLON,STAHLBRANDT, +      (CERN)
ADELMAN   65 PRL 14 1043          S L ADELMAN                  (CAMBRIDGE(CERN))
ANKENBRA  65 NC   35 1052         ANKENBRANDT,CLYDE,CORK,KEEFE,KERTH+     (LRL)
BELLETTI  65 PL   18 167          BELLETTINI,COCCONI,DIDDENS +           (CERN)
ANDERSON  66 PRL  16  855         +BLESER,COLLINS,FUJII,+            (BNL,CARN)
BLAIR     66 PRL  17  789         +TAYLOR,CHAPMAN,+  (HARWELL,QUEENMARY,RHEL)

FOLEY     67 PRL  19  397         +JONES,LINDENBAUM,LOVE,OZAKI+           (BNL)
ALMEIDA   68 PR 174 1638          +RUSHBROOKE,SCHARENGUIVEL+        (CAVE,DESY)
BELL      68 PRL  20  164         +CRENNELL,HOUGH,KARSHON,LAI+      (BNL,CUNY)
JESPERSE  68 PRL  21 1368         JESPERSEN,KANG,KERNAN+          (IOWA STATE)
LAMSA     68 PR 166 1395          +CASON,BISWAS,DERADO,GROVES,+  (NOTRE DAME)
SHAPIRA   68 PRL  21 1835         +BENARY,EISENBERG,RONAT,YAFFE+         (REHO)
TAN       68 PL 28B 195           TAN,PERL,MARTIN,VHINOWSKU +  (SLAC+LRL+UCI)
RHODE     69 PR 187 1844          RHODE, LEACOCK, KERNAN, JESPERSEN,+     (ISU)
ANDERSON  70 PRL  25 699          +BLESER,BLIEDEN,COLLINS++          (BNL,CARN)

BALLAM    71 PR D4 1946           +CHADWICK,GUIRAGOSSIAN,JOHNSON,++     (SLAC) I
BEKETOV   71 SJNP 13 605          ,ZOMBKOVSKII,KONOVALOV,KRUCHININ,++  (ITEP)IJ
BOESEBEC  71 NP B33 445           BOESEBECK,GRAESSLER,KRAUS,+++      (ABBCHLV) I
MA        71 PRL  26  333         +COLTON                             (MSU+LBL)I
RUSHBROO  71 PR D4 3273           RUSHBROOKE,WILLIAMS+BAREFORD++  (CAVE,LOIC) IJ
EDELSTEI  72 PR D5 1073           EDELSTEIN,CARRIGAN,HIEN,MCMAHON,+(CARN+BNL)
GAGE      72 NP B46 21            W GAGE,E COLTON,W CHINOWSKI             (LBL)
LISSAUER  72 PRD 6 1852           +FIRESTONE,GINESTET,GOLDHABER,TRILLING(LBL)IJP
KARSHON   72 NP B37 371           +YEKUTIELI,YAFFE,SHAPIRA,RONAT,+      (REHO) I
RONAT     72 NP B38 20            +EISENBERG,LYONS,SHAPIRA,TOAFF+       (REHO)
YEKUTIEL  72 NP B40 77            YEKUTIELI,YAFFE,SHAPIRA,RONAT +       (REHO)

BERLAND   74 NP B75 93            BERLAND,HABER,HODOUS,HULSIZER,+        (MIT)I
    ALSO  74 PL 51B 187           BERLAND,HABER,HODOUS,HULSIZER,+        (MIT)I
LICHTMAN  74 NP B81 31            LICHTMAN,BISWAS,CASON,KENNEY,MCGAHAN+(NDAM)I

BLOBEL    75 NP B97 201           +ESKREYS,FESEFELDT,FRANZ+  (BONN+HAMB+MPIM)IJP
BRAUN2    75 NP B95 503           +GERBER,MAURER,MICHALON,SCHIBY+ STBRB,LPNP I
CAVALLI   75 LNC 14 353           CAVALLI-SFORZA,CONTA+            (PAVIA+PRIN)
    ALSO  75 LNC 14 345+359       CAVALLI-SFORZA,CONTA+            (PAVIA+PRIN)
MUSGRAVE  75 NP B87 365           +PEETERS,SCREINER,WHITMORE,YUTA         (ANL)
STRACHMA  75 NP B98 120           STRACHMAN,BRAUN,GERBER,MAURER+  (LPNP+STRB)I
    ALSO  76 NP B107 330          STRACHMAN                             (LPNP)I

ATHERTON  76 NP B103 381          ATHERTON,FRENCH,SKURA,BOHM+      (CERN+PRAG)
RUSHBROO  76 PRD 13 1835          RUSHRBOOKE,RAJA,ANSORGE,CARTER,NEALE (CAVE) JP
APPLE     77 LNC 18 167           +ASH,CHENG,COYNE,GROSSMAN+       (PRIN+PAVIA)
HEINEN    77 NP B122 443          +ENGELEN,KITTEL,METZGER+   (NIJM+AMST+CERN)IJP

CHADWICK  78 PRD 17 1713          +CARROLL,CHALOUPKA,BALLAM+   (SLAC+CIT+LBL)IJP
EKELOF    78 NP B132 212          +HERZ,HAGBERG,KULLANDER+   (CERN+UPPS+LOUC)IJ
KENNEDY   78 PRD 17 2888          +ZEMANY,BEAUFAYS,KEY,LUSTE,PRENTICE+ (TNTO)
APELDOOR  79 NP B156 111          VAN APELDOORN,HARTING,HOLTHUIZEN+      (AMST)
HIROSE    79 NC 50A 120           +KANAI,KITAMURA,KOBAYASHI              (TOKY)I

                                  PAPERS NOT REFERRED TO IN DATA CARDS

GELLERT   66 PRL  17 884          +SMITH,WOJCICKI,COLTON,SCHLEIN + (LRL,UCLA)
ALBERI    68 PR 176 1631          +APPEL,BUDNITZ,CHEN,DUNNING,GOITEIN+ (HARV)
WALKER    68 PRL  20 133          +THOMPSON,ROBERTSON,OH,LEE,HARTUNG,+ (WISC)
CLEGG     69 NP B13 222           CLEGG                                  (LANC)
ALEXANDE  73 NP B52 221           ALEXANDER,BENARY+(TEL-AVIV+HEIDELBERG+DESY)
ANSORGE   73 NP B63 93            ANSORGE,MADEN,NEALE,RUSHBROOKE         (CAVE)
BEAUPRE   73 NP B66 93                  (AACH+BERL+BONN+CERN+NDAM+PENN+TOHO)I
COOPER    74 NP B79 259           COOPER,SEIDL,VANDERVELDE             (MICH)IJP
DEUTSCHM  75 NP B99 397           DEUTSCHMANN+(AACH+BONN+BERL+CERN+CRAC+HEID)
OCHS      75 NP B86 253           +DAVIDSON,DZIERBA,FIRESTONE+ (CIT+SLAC+LBL)IJP

CARNEY    76 NP B110 248          +COLLEY,JONES,KENYON+ (BIRM+BRUX+CERN+MONS)IJP
DEKERRET  76 PL 63B 477,483       +NAGY,REGLER,BRANDT+    (CERN+HAMB+IPN+VIEN)
RUSHBROO  76 PRD 13 1835          RUSHBROOKE,RAJA,ANSORGE,CARTER,NEALE (CAVE)IJP
SOTIRIOU  76 NP B107 457          D.SOTIRIOU                           (CERN)IJP
BACON     77 NC 42A 431           +BARNHAM,DORNAN,EASON,POLLOCK+       (LCIC)IJP
HARRIS    77 NP B119 189          +LUBATTI,MORIYASU,BINGHAM+          (WASH+UCB)
OTTER     77 NP B130 349          +RUDOLPH,WIECZOREK+   (AACH+BERL+BONN+CERN)IJP
BIEL      78 PRD 18 3079          +FERBEL,SLATTERY+      (ROCH+NWES+FNAL+SLAC)
    ALSO  76 PRL 36 504,507       BIEL,BLESER,FERBEL+    (ROCH+FNAL+SLAC+NWES)
GOGGI1    78 PL 79B 165           +CAVALLI-SFORZA,CONTA+            (CERN+PAVI)
    ALSO  77 PL 72B 261           GOGGI,MANTOVANI,CAVALLI-SFORZA+ (CERN+PAVI)
GOGGI2    78 NP B143 365          +CAVALLI-SFORZA,CONTA+            (CERN+PAVI)
IDSCHOK   78 NC 48A 395           +SCHRODER,BLOBEL,FRANZ+     (BONN+HAMB+MPIM)IJP
    ALSO  75 BLOBEL
OTTER     78 NP B139 365          +RUDOLPH+        (AACH+BERL+CERN+LOIC+VIEN)IJP
MUHLEMAN  78 NP B133 189          MUHLEMANN,CARITHERS,FERBEL,LAM+ (ROCH+MCGI)
BAKKEN    79 NC 49A 465           +JACOBSEN,GENNOW+          (OSLO+STOH+HELS+ABO)
GOGGI     79 NP B161 14           +CONTA,FRATERNALI,LIVAN+    (CERN+PAVI+TRST)
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N(1520)

62 N*1/2(1520, JP=3/2-) I=1/2 **D'_{13}**

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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62 N*1/2(1520) MASS (MEV)

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M         (1530.0)                      BRANDSEN  65 RVUE    PHASE-SHIFT ANAL  9/66
M         (1536.0)                      ROPER     65 RVUE    PHASE-SHIFT ANAL  9/66
M   1     (1510.0)                      BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M   1          WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M   3     (1541.0)                      DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M   6     (1523.0)                      AYED      70 IPWA                      1/71
M   6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   4     (1512.0)                      DAVIES    70 RVUE    P-S ANAL   SOL A  8/69
M   7     (1520.)                       ALMEHED   72 IPWA                      2/72
M          1501. TO 1503.               CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
M    L     1524. OR 1520.               LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.     11/75
M         (1525.)                       AYED      76 IPWA                     11/77
M         (1503.)                       BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
M         (1510.)                       BERENDS   77 IPWA    PI-N PHOTO-PROD   1/78
M   8     (1510.)                       LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M   8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M   8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                           11/77
M    A    (1503.)                       BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
M    A  SUPERSEDES BARBOUR 76.                                                 3/79*
M          1525.       15.              CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
M          1519.        4.              HOEHLER   79 IPWA    PI N TO PI N     12/79*
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
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62 N*1/2(1520) WIDTH (MEV)

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W   1      (125.0)                      BAREYRE   68 RVUE                     11/67
W   3      (149.0)                      DONNACH1  68 RVUE                      6/68
W   6      (131.0)                      AYED      70 IPWA                      1/71
W   4      (106.0)                      DAVIES    70 RVUE    P-S ANAL   SOL A
W   7      (120.)                       ALMEHED   72 IPWA                      2/72
W           115. TO  150.               CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
W    L      120. OR  150.               LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W          (122.)                       AYED      76 IPWA                     11/77
W          (137.)                       BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
W          (105.)                       BERENDS   77 IPWA    PI-N PHOTO-PROD   1/78
W   8      (110.)                       LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W    A     (135.)                       BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
W          (183.)                       BAKER     79 DPWA  0 PI- P TO ETA N   12/79*
W           125.       25.              CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
W           114.        7.              HOEHLER   79 IPWA    PI N TO PI N     12/79*
W          . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
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Data Card Listings

For notation, see key at front of Listings.

Baryons

N(1520)

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                    62  N*1/2(1520) REAL PART OF POLE POSITION (MEV)        11/75

RE          (1514.)                    LONGACRE  75 IPWA    PI N TO 2PI N   11/75
RE   8       1508. OR 1505.            LONGACRE  77 IPWA    PI N TO 2PI N   11/77
RE          (1510.)                    CUTKOSKY  79 IPWA    PI N TO PI N    12/79*

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                    62  N*1/2(1520) -2*IMAG PART OF POLE POSITION (MEV)     11/75

IM          (146.)                     LONGACRE  75 IPWA    PI N TO 2PI N   11/75
IM   8       109. OR 107.              LONGACRE  77 IPWA    PI N TO 2PI N   11/77
IM          (114.)                     CUTKOSKY  79 IPWA    PI N TO PI N    12/79*

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                    62  N*1/2(1520) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          (34.)                     CUTKOSKY  79 IPWA    PI N TO PI N    12/79*

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                    62  N*1/2(1520) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR          (-8.)                     CUTKOSKY  79 IPWA    PI N TO PI N    12/79*

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                    62  N*1/2(1520) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N*1/2(1520) INTO PI N                            139+ 938
P2      N*1/2(1520) INTO N*3/2(1232) PI                 1232+ 139
P3      N*1/2(1520) INTO N PI PI                         938+ 139+ 139
P4      N*1/2(1520)+ INTO NEUTRON PI+                    939+ 139
P5      N*1/2(1520)+ INTO PROTON PI+ PI-                 938+ 139+ 139
P6      N*1/2(1520) INTO N ETA                           939+ 548
P7      N*1/2(1520) INTO N EPSILON                       938+1300
P8      N*1/2(1520) INTO N RHO                           938+ 776
P9      N*1/2(1520) INTO GAM P, HELICITY=1/2               0+ 938
P10     N*1/2(1520) INTO GAM P, HELICITY=3/2               0+ 938
P11     N*1/2(1520) INTO GAM N, HELICITY=1/2               0+ 939
P12     N*1/2(1520) INTO GAM N, HELICITY=3/2               0+ 939
P13     N*1/2(1520) INTO K LAMBDA                        497+1115
P14     N*1/2(1520) INTO N*3/2(1232) PI,S-WAVE          1232+ 139
P15     N*1/2(1520) INTO N*3/2(1232) PI,D-WAVE          1232+ 139
P16     N*1/2(1520) INTO N RHO,S=3/2,S-WAVE              938+ 776

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                    62  N*1/2(1520) BRANCHING RATIOS

R1      N*1/2(1520) INTO (PI N)/TOTAL                      (P1)
R1   1          (0.54)                 BAREYRE   68 RVUE                    11/67
R1   3          (0.509)                DONNACH1  68 RVUE                     6/68
R1   6          (0.593)                AYED      70 IPWA                     1/71
R1   4          (0.45)                 DAVIES    70 RVUE    P-S ANAL  SOL A  8/69
R1   7 .        (0.58)                 ALMEHED   72 IPWA                     2/72
R1               (.56)                 AYED      76 IPWA                    11/77
R1                .56       .06        CUTKOSKY  79 IPWA    PI N TO PI N    12/79*
R1                .54       .03        HOEHLER   79 IPWA    PI N TO PI N    12/79*
R1      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
R1
R1   ALMOST THE ENTIRE INELASTICITY IS IN N PI PI (ONLY N ETA COULD COMPETE,
R1   AND IT DOESNT).  THE N PI PI SEEMS TO BE MAINLY N*3/2(1232) PI, IN BOTH
R1   S AND D WAVES.
R1           . . . . . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R2      N*1/2(1520) INTO (N*3/2(1232) PI)/TOTAL            (P4)
R2              0.20      0.05         KIRZ      66 HBC   0 ASSUMING R1=0.72  9/66
R2              DOMINANT INEL DECAY    OLSSON    66 RVUE    PI P TO PI PI N   9/66
R2   D          (0.40)                 DIEM      70 IPWA    3 BODY ANALYSIS   1/71
R2   D       ASSUMING  R1= 0.5

R3      N*1/2(1520) INTO (N*3/2(1232) PI)/(N PI PI)        (P2)/(P3)
R3                LARGE                THURNAUER 65 RVUE -                  11/67
R3                LARGE                NAMYSLOWS 66 RVUE -                  11/67
R3                LARGE                ROBERTS   67 RVUE -                  11/67
R3                LARGE                ROSENFELD 67 RVUE -                  11/67
R3                LARGE                MORGAN    68 RVUE    ISOBAR MODEL     6/68

R4      N*1/2(1520) INTO (N EPSILON)/TOTAL                 (P7)
R4              PROBABLY PRESENT       MORGAN    68 RVUE    ISOBAR MODEL     6/68
R4   D          (0.02)                 DIEM      70 IPWA    3 BODY ANALYSIS   1/71
R4   D       ASSUMING  R1= 0.5

R5      N*1/2(1520) INTO (N ETA)/TOTAL                     (P6)
R5   D          (0.006)   APPROX       DAVIES    67 RVUE                    11/67
R5    DAVIES 67 GIVES SEVERAL VALUES DEPENDING ON INPUT DATA.  ALL ARE SMALL
R5   B          (0.014)                BOTKE     69 MPWA    T POLE+ RESON.   10/69
R5   B          (0.003)  (0.001)       DEANS     69 MPWA    T POLE+ RESON.    5/70
R5   B          (0.002)OR 0.004        CARRERAS  70 MPWA    T POLE+ RESON.    5/70
R5   B    PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING
R5              SEEN                   LEMOIGNE  73 DPWA    1488 TO 1685 MEV  2/74

R6      N*1/2(1520) INTO (N RHO )/TOTAL                    (P8)
R6   D          (0.07)                 DIEM      70 IPWA    3 BODY ANALYSIS   1/71
R6   D       ASSUMING  R1= 0.5

R7      N*1/2(1520) FROM PI N TO K LAMBDA                  SQRT(P1*P13)       4/75
R7 C            -.076      .032        DEVENISH  74       .0 FIXED T DISP REL 4/75
R7 C      EXTRAPOLATION OF PARAMETRIZED AMPLITUDE BELOW THRESHOLD.            4/75

R8      N*1/2(1520) FROM PI N INTO N EPSILON               SQRT(P1*P7)       11/75
R8    L         (0.0) OR  +.17         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R8   8          (+.13)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R9      N*1/2(1520) FROM PI N TO N*3/2(1232) PI,S-WAVE     SQRT(P1*P14)      11/75
R9    L         (+.27)OR  +.24         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R9   8          (+.26)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R9   8    LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R10     N*1/2(1520) FROM PI N TO N*3/2(1232) PI,D-WAVE     SQRT(P1*P15       11/75
R10 L           (+.24)OR  +.30         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R10 8           (+.21)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R10 8     LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R11     N*1/2(1520) FROM PI N TO N RHO,S=3/2,S-WAVE        SQRT(P1*P16)      11/75
R11 L           (+.32)OR  +.24         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R11 8           (+.35)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R11 8     LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R12     N*1/2(1520) FROM PI N TO ETA N                     SQRT(P1*P6)        1/76
R12  9          (+.011)OR +.058        FELTESSE  75 DPWA  0 1488 TO 1745 MEV  1/76
R12  9    SUPERSEDES LEMOIGNE 73, USES M AND W OF AYED 76.                   11/77
R12             (.02)                  BAKER     79 DPWA  0 PI- P TO ETA N   12/79*

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                    62  N*1/2(1520) PHOTON DECAY AMPL(GEV**-1/2)

     FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
   REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*1/2(1520) INTO GAM P, HELICITY=1/2  (GEV**-1/2)
A1               .010      .022        DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A1             (-.026)                 HEMMI1    73       + FWD PI0 PHTOPROD  2/74
A1              -.026      .015        MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A1              -.008      .015        DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A1              -.019      .008        KNIES     74 DPWA    PI N PHOTO PROD   2/74
A1              -.006      .006        METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A1               .000      .006        MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A1              -.009      .004        CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A1             (+.011)                 KRIVETS   75 DPWA    PI-N PHOTO-PROD   1/78
A1             (-.012)                 BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A1              -.005      .005        FELLER    76 DPWA    PI N PHOTO-PROD   2/77
A1              -.003      .003        AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 1 12/79*
A1              -.030      .002        AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 2 12/79*
A1             (-.021)                 BERENDS   77 IPWA    PI-N PHOTO-PROD   1/78
A1   A          -.016      .008        BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A1   N         (-.008)                 NOELLE    78         PI-N PHOTO-PROD   1/80*
A1   N  CONVERTED TO OUR CONVENTIONS USING M=1.528, W=.187 FROM NOELLE 78.    1/80*
A1           . . . . . . . . . .
A1   AVERAGE MEANINGLESS (SCALE FACTOR = 3.5)

A2      N*1/2(1520) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2               .180      .017        DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A2              +.194      .031        MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A2               .171      .012        DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A2               .169      .012        KNIES     74 DPWA    PI N PHOTO PROD   2/74
A2              +.165      .011        METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A2               .174      .006        MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A2              +.162      .004        CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A2             (+.138)                 KRIVETS   75 DPWA    PI-N PHOTO-PROD   1/78
A2             (+.158)                 BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A2              +.164      .008        FELLER    76 DPWA    PI N PHOTO-PROD   2/77
A2              +.182      .006        AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 1 12/79*
A2              +.133      .002        AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 2 12/79*
A2             (+.075)                 BERENDS   77 IPWA    PI-N PHOTO-PROD   1/78
A2   A          +.157      .007        BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A2   N          (.206)                 NOELLE    78         PI-N PHOTO-PROD   1/80*
A2   N  CONVERTED TO OUR CONVENTIONS USING M=1.528, W=.187 FROM NOELLE 78.    1/80*
A2           . . . . . . . . . .
A2   AVERAGE MEANINGLESS (SCALE FACTOR = 4.1)

A3      N*1/2(1520) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3              -.075      .037        DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A3              -.085      .014        MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A3 2            +.037      .012        ROSSI     73 DPWA  0 GAM N TO PI- P    4/75
A3 2    CONVERTED TO OUR CONVENTIONS USING M AND W FROM ROSSI73 AND X=.56     4/75
A3              (0.)                   BENEVENT  74 DPWA  0 GAM N TO PI- P    4/75
A3              -.089      .019        DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A3              -.077      .005        KNIES     74 DPWA    PI N PHOTO PROD   2/74
A3              -.066      .010        METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A3              -.088      .007        MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A3              -.067      .004        CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A3             (-.056)                 BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A3   A          -.055      .014        BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A3   N         (-.060)                 NOELLE    78         PI-N PHOTO-PROD   1/80*
A3   N  CONVERTED TO OUR CONVENTIONS USING M=1.528, W=.187 FROM NOELLE 78.    1/80*
A3           . . . . . . . . . .
A3   AVERAGE MEANINGLESS (SCALE FACTOR = 3.6)

A4      N*1/2(1520) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4              -.126      .028        DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A4 8           (-.087)                 HEMMI2    73         0 GAM N TO PI0 N  4/75
A4 8    CONVERTED TO OUR CONVENTIONS USING M AND W FROM WALKER69 AND X=.56    4/75
A4 2            -.016      .016   .018 ROSSI     73 DPWA  0 GAM N TO PI- P    4/75
A4              -.124      .013        MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A4 5           (-.035)                 BENEVENT  74 DPWA  0 GAM N TO PI- P    4/75
A4 5    CONVERTED TO OUR CONVENTIONS USING M=1520 MEV, W=120 MEV, X=.56       4/75
A4              -.155      .019        DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A4              -.120      .010        KNIES     74 DPWA    PI N PHOTO PROD   2/74
A4              -.118      .013        METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A4              -.119      .025        MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A4              -.133      .003        CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A4             (-.136)                 BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A4   A          -.141      .015        BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A4   N         (-.127)                 NOELLE    78         PI-N PHOTO-PROD   1/80*
A4   N  CONVERTED TO OUR CONVENTIONS USING M=1.528, W=.187 FROM NOELLE 78.    1/80*
A4           . . . . . . . . . .
A4   AVERAGE MEANINGLESS (SCALE FACTOR = 2.9)


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REFERENCES FOR N*1/2(1520)

SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.


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BRANDSEN 65 PR 139 B1566      +ODONNELL, MOORHOUSE            (DURHAM, RHEL)IJP
ROPER    65 PR 138 B190       LD ROPER,RM WRIGHT,BT FELD      (LRL-LVMR,MIT)IJP
THURNAUE 65 PRL 14 985        P G THURNAUER                            (ROCH)

KIRZ     66 PRIVATE COMM      J KIRZ                                    (LRL)
    NUMBER EXTRACTED FROM DATA DISCUSSED IN KIRZ 63. Z 63.
NAMYSLOW 66 PR 157 1328       NAMYSLOWSKI,RAZMI,ROBERTS  (STAN,EDIN,LCIC)
CLSSCN   66 PR 145 1309       M G OLSSON, G B YODH                 (WISC,UMD)

DAVIES   67 NC 52A 1112       A T DAVIES, R G MOORHOUSE    (GLASGOW, RHEL)
ROBERTS  67 PREPRINT          R G ROBERTS                           (DURHAM)
ROSENFEL 67 IRVINE CONF       A H ROSENFELD, P SODING                   (LRL)

BAREYRE  68 PR 165 1731       P BAREYRE, C BRICMAN, G VILLET     (SACLAY)IJP
DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139        DONNACHIE  RAPPORTEUR.S TALK             (GLAS)
    ALSO 68 THESIS            R G KIRSOPP                              (EDIN)
MORGAN   68 PR 166 1731       D MORGAN                                 (RHEL)

BOTKE    69 PR 180 1417       J C BOTKE                                (UCSB)
DEANS    69 PR 185 1797       S DEANS, J WOOTEN             (UNIV S FLORIDA)

AYED     70 KIEV CONF         R AYED,P BAREYRE, G VILLET            (SACL)IJP
CARRERAS 70 NP 16B 35         B CARRERAS, A DONNACHIE            (DARE,MCHS)
DAVIES   70 NP B21 359        A DAVIES                                 (GLAS)
DIEM     70 KIEV CONF.        + SMADJA, CHAVANON, DELER, DOLBEAU+  (SACL)
ALMEHED  72 NP B40 157        +LOVELACE                       (LUND,RUTG)IJP
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Baryons
N(1520), N(1535)

Data Card Listings
For notation, see key at front of Listings.

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DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+           (KYOTO+SAGA+KEK+TOKY)IJP
HEMMI2   73 NP B55 333         +INAGAKI,KIKUCHI,MAKI,MIYAKE+ (KYOTO,TOKYO)IJP
LEMOIGNE 73 PURDUE CONF. 93    +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK               (GLAS+LBL)IJP
ROSSI    73 NC 13A 59          +PIAZZA,SUSINNO,+     (RCMA,FRAS,NAPL,PAVIA)IJP
    ALSO 71 LNC 2 1183         CARBONARA,FIORE,+     (NAPL,FRAS,PAVIA,RCMA)IJP

BENEVENT 74 NC 19A 529         BENEVENTANO,DANGELO,NOTARISTEFANI,+  (RCMA)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN          (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680         KNIES,MOORHOUSE,OBERLACK           (LBL,GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                  (CIT)IJP
MOORHOUS 74 PRD 9 1            MOORHOUSE,OBERLACK,ROSENFELD       (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                           (GLAS)IJP
FELTESSE 75 NP B93 242         +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS  75 SJNP 20 430        +MIROSHNICHENKO,NIKIFOROV,SANIN+       (KIEV)IJP
    ALSO 74 SJNP 19 112        KRIVETS,NIKIFOROV,SANIN,SHALATSKII     (KIEV)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+        (LBL,SLAC)IJP
    ALSO 78 PRD 17 1795        LONGACRE,LASINSKI,ROSENFELD+       (LBL,SLAC)

AYED     76 CEA-N-1921         AYED (THESIS)                          (SACL)IJP
BARBOUR  76 NP B111 358        I. M. BARBOUR,R. L. CRAWFORD           (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP

AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
BERENDS  77 NP B136 317        F.A.BERENDS,A.DONNACHIE           (LEID,MCHS)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                       (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET          (SACL)IJP

BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS               (GLAS)
NOELLE   78 PTP 60 778         P. NOELLE                              (NAGO)
BAKER    79 NP B156 93         +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PRD 20 2839        +FORSYTH,HENDRICK,KELLY            (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN          /KARLSRUHE IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS

KIRZ     63 PR 130 2481        J KIRZ, J SCHWARTZ, R D TRIPP          (LRL)
BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET         (SACLAY)IJP
CROUCH   65 DESY CONF II 21    +   (BROWN,CEA,HARVARD,MIT,PADOVA,WEIZMANN)
DERADO   65 ATHENS CONF 244    +KENNEY,LAMSA, +        (NOTRE DAME,KENTUCKY)
MERLO    66 P ROY SOC 289 489  J P MERLO, G VALLADAS                (SACLAY)
    THE ABOVE PAPERS DISCUSS INELASTIC CHANNELS NEAR THE REONANCE.
JOHNSON  67 UCRL-17683 THESIS  C H JOHNSON                           (LRL)
DEANS    69 PRL 177 2623       S R DEANS                    (UNIV S FLORIDA)
DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP           (GLAS+EDIN)
WALKER   69 PR 182 1729        R L WALKER                            (CIT)IJP
AYED     70 PL 31B 598         +BAREYRE+VILLET                      (SACLAY)

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1520 MEV REGION - PRODUCTION EXPERIMENTS

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                  8  N*1/2(1520, JP=     ) I=1/2    PRODUCTION EXPERIMENTS

                SEE THE MINI-REVIEW PRECEDING THE N AND DELTA LISTINGS
                FOR A DISCUSSION OF PRODUCTION EXPERIMENTS.

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                  8  N*1/2(1520) MASS (MEV) (PROD. EXP.)

M          1507.0      6.0          A-BORELLI 67 HBC   0 PBAR P 5.7 GEV   10/71
M          1503.       6.           ANDERSON  70 MMS   - PI- P TO PI- MMS  2/71
M          1500.0     10.0          AMALDI    71 SAS     P P AT 24 GEV    10/71
M          1512.0      2.0          ELLIS     71 CNTR    MMS PP 3.7 GEV/C 10/71
M          1460. TO 1510.           MORSE     71 HBC  +0 PI-P,  7 GEV/C   11/77
M         (1510.0)   (20.0)         MORSE     71 HBC   + PI-P, 25 GEV/C   11/77
M          1501.0      5.7          EDELSTEIN 72 MMS   + PP 6 TO 30 GEV    1/73
M   1     (1500.)                   OH        72 DBC   0 PI-N TO PI-PI-P   2/73
M   1   DETERMINE J=3/2,D13 PROBABLE                                       2/73
M          1515.      11.           COOPER    74 HBC   0 D P CEX           4/75
M         (1490.)                   BRAUN1    75 HBC     PBAR P 5.7 GEV   11/75
M          1510.       7.           MUSGRAVE  75 HBC     K+ P TO K PI N   11/75
M         (1500.)                   STRACHMA  75  BC     NBAR (N PI)       1/76
M          1500.       8.           WEBB      75 ISR   + P P TO P N*       1/76
M  A       1515.       5.           ROUGE     77 OMEG  0 PI-P 9,12 GEV/C   1/78
M  A    BACKWARD PRODUCTION. PI- P --> (P PI-) PI0
M  B    1K 1515.       6.           FERRER    78 OMEG  0 PI-P 9,12 GEV/C   3/79*
M  B    BACKWARD PRODUCTION. PI- P --> (P PI-) PI+ PI-
M  C   202 1518.      10.           FERRER    78 OMEG  + PI-P 9,12 GEV/C   3/79*
M  C    BACKWARD PRODUCTION. PI- P --> (P PI+ PI-) PI-

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                  8  N*1/2(1520) WIDTH (MEV) (PROD. EXP.)

W            55.0     15.0          A-BORELLI 67 HBC   0 PBAR P 5.7 GEV   10/71
W           120.      10.           ANDERSON  70 MMS   - PI- P TO PI- MMS  2/71
W           118.0     20.0          AMALDI    71 SAS     P P AT 24 GEV    10/71
W            88.0      2.0          ELLIS     71 CNTR    MMS PP 3.7 GEV/C 10/71
W            80. TO  120.           MORSE     71 HBC   + PI-P,  7 GEV/C   11/77
W          (100.0)   (30.0)         MORSE     71 HBC   + PI-P, 25 GEV/C   11/77
W           140.0     43.0          EDELSTEIN 72 MMS   + PP 6 TO 30 GEV    1/73
W           106.      39.      33.  COOPER    74 HBC   0 D P CEX           4/75
W          (200.)                   BRAUN1    75 HBC     PBAR P 5.7 GEV   11/75
W           101.      26.           MUSGRAVE  75 HBC     K+ P TO K PI N   11/75
W           150.      50.           WEBB      75 ISR   + P P TO P N*       1/76
W  A        105.      17.           ROUGE     77 OMEG  0 PI-P 9,12 GEV/C   1/78
W  B    1K  105.      10.           FERRER    78 OMEG  0 PI-P 9,12 GEV/C   3/79*
W  C   202  112.      15.           FERRER    78 OMEG  + PI-P 9,12 GEV/C   3/79*
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED ABOVE.

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                  8  N*1/2(1520) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1      N*1/2(1520) INTO PI N                            139+ 938
P2      N*1/2(1520) INTO N*3/2(1232) PI                 1232+ 139
P3      N*1/2(1520) INTO N PI PI                         938+ 139+ 139
P4      N*1/2(1520)+ INTO NEUTRON PI+                    939+ 139
P5      N*1/2(1520)+ INTO PROTON PI+ PI-                 938+ 139+ 139
P6      N*1/2(1520) INTO N ETA                           939+ 548
P7      N*1/2(1520) INTO N PIPI(J,I=0)                   939+ 139+ 139
P8      N*1/2(1520) INTO N RHO                           938+ 776

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                  8  N*1/2(1520) BRANCHING RATIOS (PROD. EXP.)

R1      N*1/2(1520) INTO (N PI)/TOTAL                    (P1)
R1         N*(1520)  INTO   (N PI)/TOTAL   PRODUCTION EXPERIMENTS
R1           0.78      0.24            BASSOMPIE 67 HBC  +  K+P TO K* N*     11/68

R2      N*1/2(1520) INTO (NEUTRON PI+)/(P PI+ PI-)       (P4)/(P5)
R2           0.77      0.45            ALEXANDER 67 HBC  +  PP 5.5 BEV/C      9/66

R3      N*1/2(1520) INTO (N PI)/(N PI PI)                (P1)/(P3)
R3           1.25      0.44      0.71  A-BORELLI 67 HBC  0 PBAR P 5.7 BEV/C  9/66

R4      N*1/2(1520) INTO (N*3/2(1232) PI)/(N PI PI)      (P2)/(P3)
R4           0.00      0.09            A-BORELLI 67 HBC                       9/66

R5      N*1/2(1520) INTO (N PI PI)/TOTAL                 (P3)
R5          (0.08) OR LESS             BASSOMPIE 67 HBC  +  K+P TO K* N*     11/68

R6      N*1/2(1520) INTO (N ETA)/TOTAL                   (P6)
R6           0.22      0.14            BASSOMPIE 67 HBC  +  K+P TO K* N*     11/68

R7      N*1/2(1520) INTO (PI N)/(PI N*3/2(1232))         (P1)/(P2)
R7          (0.42) OR LESS             LEE       67 HBC     PI-P 3.6  GEV/C  11/67

R8      N*1/2(1520) INTO (N PIPI(J,I=0))/TOTAL           (P7)
R8                MAIN DECAY MODE      MORSE     71 HBC  +  PI-P 7,25 GEV/C  11/77

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                               REFERENCES FOR N*1/2(1520) (PROD. EXP.)

A-BORELL 67 NC 47 232          ALLES-BORELLI,FRENCH,FRISK,MICHEJDA  (CERN)
ALEXANDE 67 PR 154 1284        ALEXANDER,BENARY,CZAPEK,+  (WEIZMANN(CERN))
BASSOMPI 67 PL 25B 440         BASSOMPIERRE, +             (CERN,BRUXELLES)
LEE      67 PR 159 1156        +MOEBS,ROE,SINCLAIR,VANDER VELDE       (MICH)

ANDERSON 70 PRL 25 699         +BLESER,BLIEDEN,COLLINS++          (BNL,CARN)

AMALDI   71 PL  34B 435        +BIANCASTELLI,BOSIO,+  (I SANITA ROMA+CERN)
ELLIS    71 PRL 27 442         +MAGLICH,NOREM,SANNES,SILVERMAN        (RUTG)
MORSE    71 PR D4 133          +OH,WALKER,CARROLL,LYNCH +       (WISC+TNTO)IJ

EDELSTEI 72 PR D5 1073         EDELSTEIN,CARRIGAN,HIEN,MCMAHON,+(CARN+BNL)
JOHNSTAD 72 NP B42 588         +MOLLERUD+...+JACOBSEN(BOHR,HELS,OSLO,STOH)IJP
OH       72 PL 42B 497         +FUNG,KERNAN,POE,SCHALK,SHEN            (UCR)IJP

COOPER   74 NP B79 259         COOPER,SEIDL,VANDERVELDE               (MICH)

BRAUN1   75 NP B95 481         +GERBER,MAURER,MICHALON,SCHIBY+ (STRB,LPNP)I
MUSGRAVE 75 NP B87 365         +PEETERS,SCREINER,WHITMORE,YUTA         (ANL)
STRACHMA 75 NP B98 120         STRACHMAN,BRAUN,GERBER,MAURER+  (LPNP+STRB)I
    ALSO 76 NP B107 330        STRACHMAN                              (LPNP)I
WEBB     75 PL 55B 331         +TRILLING,TELEGDI+      (AACH+UCLA+UCR+CERN)
    ALSO 75 PL 55B 336         +TRILLING,TELEGDI+      (AACH+UCLA+UCR+CERN)

ROUGE    77 PL 69B 115         +DE ROSNY,FLEURY,RIVET+     (LPNP+CDEF+LALO)
FERRER   78 NP B142 77         +BOUQUET,D.ALMAGNE+   (LALO+CERN+CDEF+EPOL)I,JP

                               PAPERS NOT REFERRED TO IN DATA CARDS

RUSHBROO 76 PRD 13 1835        RUSHBROOKE,RAJA,ANSORGE,CARTER,NEALE (CAVE)IJP
SOTIRIOU 76 NP B107 457        D.SOTIRIOU                             (CERN)IJP
BIEL     78 PRD 18 3079        +FERBEL,SLATTERY+      (ROCH+NWES+FNAL+SLAC)
    ALSO 76 PRL 36 504,507     BIEL,BLESER,FERBEL+    (ROCH+FNAL+SLAC+NWES)
CHADWICK 78 PRD 17 1713        +CARROLL,CHALOUPKA,BALLAM+   (SLAC+CIT+LBL)IJP
GOGGI2   78 NP B143 365        +CAVALLI-SFORZA,CONTA+             (CERN+PAVI)
GOGGI    79 NP B161 14         +CONTA,FRATERNALI,LIVAN+    (CERN+PAVI+TRST)

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N(1535) S'_{11}

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   63  N*1/2(1535, JP=1/2-) I=1/2

       THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.
       IT IS STRONGLY COUPLED TO THE ETA NEUTRON CHANNEL,
       WITH A BRANCHING RATIO OF 0.70 (BHANDARI77 AND
       R. BHANDARI, PRIV. COMM., 1979).

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                  63  N*1/2(1535) MASS (MEV)

M          (1519.0)                 HENDRY    65 RVUE    ETA N + S11 PI N  9/66
M          (1570.0)                 MICHAEL   66 RVUE    FITS BAREYRE S11  7/66
M   N      (1557.0) OR  1565.0      UCHIYAMA- 66 RVUE    FITS N ETA DATA   9/66
M   N       FITTING GIVES TWO SOLUTIONS.  PROBLEMS MATCHING PI P PHASE SHIFT
M   1      (1535.0)                 BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M   1               WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M   3      (1591.0)                 DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M          (1535.0)    (10.0)       DELCOURT  69 CNTR    PHOTOPRODUCT.     8/69
M   6      (1534.0)                 AYED      70 IPWA                      1/71
M   6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   4      (1502.0)                 DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M   7      (1500.)                  ALMEHED   72 IPWA                      2/72
M    2     (1551.)                  HICKS     73 MPWA    GAM P-ETA P       9/73
M    2  ONLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS.    9/73
M    2  M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII.   9/73
M           1507. TO 1530.          CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
M    L      1520. OR 1510.          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75. 11/75
M          (1519.)                  AYED      76 IPWA                     11/77
M          (1501.)                  BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
M          (1500.)                  BERENDS   77 IPWA    PI-N PHOTO-PROD   1/78
M           1547.        6.         BHANDARI  77 DPWA  0 USES ETA N CUSP   1/78
M   8      (1520.)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M   8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M   8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                        11/77
M    E     (1511.)                  BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
M    E  SUPERSEDES BARBOUR 76.                                             3/79*
M           1540.       20.         CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
M           1526.        7.         HOEHLER   79 IPWA    PI N TO PI N     12/79*
M           . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

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                  63  N*1/2(1535) WIDTH (MEV)

W          (130.0)                  HENDRY    65 RVUE                      9/66
W          (130.0)                  MICHAEL   66 RVUE                      7/66
W   N      (156.0) OR  144.0        UCHIYAMA- 66 RVUE    SEE NOTE ON MASS  9/66
W   1      (155.0)                  BAREYRE   68 RVUE                     11/67
W   3      (268.0)     APPROX       DONNACH1  68 RVUE                      6/68
W          (120.0)                  DELCOURT  69 CNTR    PHOTOPRODUCT.     8/69
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Data Card Listings

For notation, see key at front of Listings.

Baryons
N(1535)

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W   6      (96.0)                  AYED       70 IPWA                        1/71
W   4      (36.0)                  DAVIES     70 RVUE   P-S ANAL  SOL A     8/69
W   7      (50.)                   ALMEHED    72 IPWA                        2/72
W    2    (134.)                   HICKS      73 MPWA   GAM P-ETA P         9/73
W          114. TO  167.           CRAWFORD   75 DPWA   PI N PHOTO-PROD     1/76
W    L      75. OR  100.           LONGACRE   75 IPWA   PI N TO 2PI N      11/75
W          (75.)                   AYED       76 IPWA                      11/77
W         (128.)                   BARBOUR    76 DPWA   PI N PHOTO-PROD     1/76
W          (57.)                   BERENDS    77 IPWA   PI-N PHOTO-PROD     1/78
W          139.        33.         BHANDARI   77 DPWA 0 USES ETA N CUSP     1/78
W   8     (135.)                   LONGACRE   77 IPWA   PI N TO 2PI N      11/77
W    E    (132.)                   BARBOUR    78 DPWA   PI-N PHOTO-PROD    3/79*
W         (180.)                   BAKER      79 DPWA 0 PI- P TO ETA N    12/79*
W          270.        50.         CUTKOSKY   79 IPWA   PI N TO PI N      12/79*
W          120.        20.         HOEHLER    79 IPWA   PI N TO PI N      12/79*
W          . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 2.0)
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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            63  N*1/2(1535) REAL PART OF POLE POSITION (MEV)            11/75

RE        (1496.)                  LONGACRE   75 IPWA   PI N TO 2PI N      11/75
RE         1519.        4.         BHANDARI   77 DPWA 0 USES ETA N CUSP     1/78
RE   8     1525. OR 1527.          LONGACRE   77 IPWA   PI N TO 2PI N      11/77
RE        (1465.)                  CUTKOSKY   79 IPWA   PI N TO PI N      12/79*

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            63  N*1/2(1535) -2*IMAG PART OF POLE POSITION (MEV)         11/75

IM         (103.)                  LONGACRE   75 IPWA   PI N TO 2PI N      11/75
IM          140.       32.         BHANDARI   77 DPWA 0 USES ETA N CUSP     1/78
IM   8      135. OR 123.           LONGACRE   77 IPWA   PI N TO 2PI N      11/77
IM         (256.)                  CUTKOSKY   79 IPWA   PI N TO PI N      12/79*

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            63  N*1/2(1535) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER         20.        21.         BHANDARI   77 DPWA 0 USES ETA N CUSP     1/78
RER        (48.)                   CUTKOSKY   79 IPWA   PI N TO PI N      12/79*

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            63  N*1/2(1535) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         13.         8.         BHANDARI   77 DPWA 0 USES ETA N CUSP     1/78
IMR        (-67.)                  CUTKOSKY   79 IPWA   PI N TO PI N      12/79*

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            63  N*1/2(1535) PARTIAL DECAY MODES

                                                    DECAY MASSES
P1     N*1/2(1535) INTO PI N                        139+ 938
P2     N*1/2(1535) INTO N ETA                       939+ 548
P3     N*1/2(1535) INTO N PI PI                     938+ 139+ 139
P4     N*1/2(1535) INTO N EPSILON                   938+1300
P5     N*1/2(1535) INTO N*3/2(1232) PI             1232+ 139
P6     N*1/2(1535) INTO N RHO                       938+ 776
P7     N*1/2(1535) INTO GAM P, HELICITY=1/2           0+ 938
P8     N*1/2(1535) INTO GAM N, HELICITY=1/2           0+ 939
P9     N*1/2(1535) INTO K LAMDBA                    497+1115
P10    N*1/2(1535) INTO N RHO,S=1/2,S-WAVE          938+ 776

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            63  N*1/2(1535) BRANCHING RATIOS

R1     N*1/2(1535) INTO (PI N)/TOTAL                       (P1)
R1          (0.69)                 HENDRY     65 RVUE                       9/66
R1          (0.32)                 MICHAEL    66 RVUE                       9/66
R1   N      (0.71) OR  0.28        UCHIYAMA-  66 RVUE   SEE NOTE ON MASS    9/66
R1          (0.31) OR  0.43        DAVIES     67 RVUE   PIP TO N ETA,B,C  11/67
R1   3      (0.696)                DONNACH1   68 RVUE                       6/68
R1          (0.33)                 DELCOURT   69 CNTR                       8/69
R1   6      (0.397)                AYED       70 IPWA                       1/71
R1   4      (0.36)                 DAVIES     70 RVUE   P-S ANAL  SOL A     8/69
R1   7      (0.25)                 ALMEHED    72 IPWA                       2/72
R1           (.34)                 AYED       76 IPWA                      11/77
R1            .297      .026       BHANDARI   77 DPWA 0 USES ETA N CUSP     1/78
R1            .45       .06        CUTKOSKY   79 IPWA   PI N TO PI N      12/79*
R1            .38       .04        HOEHLER    79 IPWA   PI N TO PI N      12/79*
R1           . . . . . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

R2     N*1/2(1535) INTO (N ETA)/TOTAL   (SEE R8 ALSO.)  (P2)
R2          DOMINANT INEL DECAY        HENDRY     65 RVUE                       9/66
R2          (0.68)                 MICHAEL    66 RVUE                       9/66
R2   N      (0.29) OR  0.71        UCHIYAMA-  66 RVUE   SEE NOTE ON MASS    9/66
R2          (0.69) OR  0.45        DAVIES     67 RVUE   PIP TO N ETA,B,C  11/67
R2   B      (0.4)    (0.1)         DEANS      69 MPWA   T POLE+ RESON.      5/70
R2          (0.66)                 DELCOURT   69 MPWA                       8/69
R2   B      (0.69) OR  0.696       CARRERAS   70 MPWA   T POLE+ RESON.      5/70
R2   B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING
R2       THE VALUES OF R2 LISTED ABOVE ARE INCOMPATIBLE WITH THE RESULTS
R2       OF DIEM ET AL. (70)
R2       THE BRANCHING RATIO INTO ETA NEUTRCN FOUND BY BHANDARI 77 IS      12/79*
R2       0.70 (R.BHANDARI, PRIV. COMM., 1979).                             12/79*

R3     N*1/2(1535) INTO (N*3/2(1232) PI)/TOTAL             (P5)
R3   D      (0.07)                 DIEM       70 IPWA   3 BODY ANALYSIS     1/71
R3   D     ASSUMING  R1= 0.34

R4     N*1/2(1535) INTO (N EPSILON)/TOTAL                  (P4)
R4   D      (0.26)                 DIEM       70 IPWA   3 BODY ANALYSIS     1/71
R4   D     ASSUMING  R1= 0.34

R5     N*1/2(1535) INTO (N RHO )/TOTAL                     (P6)
R5   D      (0.20)                 DIEM       70 IPWA   3 BODY ANALYSIS     1/71
R5   D     ASSUMING  R1= 0.34

R6     N*1/2(1535) INTO GAMMA PROTON/TOTAL                 (P7)             9/73
R6    5      .0042     .0014       DEANS      72 MPWA   P ETA PHOTOPROD.    9/73
R6    5  BR=(DEANS72 RADIATIVE WIDTH)/(NOMINAL FULL WIDTH=100 MEV)          9/73
R6    5  THE HICKS73 ENTRY UNDER R7 IS A MORE RECENT RESULT BY SAME GROUP.  9/73

R7     N*1/2(1535) FROM GAMMA PROTON TO ETA PROTON       SQRT(P2*P7)        9/73
R7    2      (.0366)               HICKS      73 MPWA   GAM P-ETA P         9/73

R8     N*1/2(1535) FROM PI N INTO ETA N  (SEE R2 ALSO.) SQRT(P1*P2)         2/74
R8          (+.43)                 LEMOIGNE   73 DPWA   1488 TO 1685 MEV   2/74
R8   A      (+.48)                 FELTESSE   75 DPWA 0 1488 TO 1745 MEV 11/75
R8   A   SUPERSEDES LEMOIGNE 73, USES M AND W OF AYED 76.                  11/77
R8          (+.33)                 BAKER      79 DPWA 0 PI- P TO ETA N    12/79*

R9     N*1/2(1535) FROM PI N TO K LAMBDA                  SQRT(P1*P9)        4/75
R9 C        -.691      .214        DEVENISH   74         0 FIXED T DISP REL  4/75
R9 C     EXTRAPOLATION OF PARAMETRIZED AMPLITUDE BELOW THRESHOLD.           4/75

R10    N*1/2(1535) FROM PI N TO N*3/2(1232) PI            SQRT(P1*P5)       11/75
R10  L      (0.0) OR  -.06         LONGACRE   75 IPWA   PI N TO 2PI N      11/75
R10 8       (.00)                  LONGACRE   77 IPWA   PI N TO 2PI N      11/77

R11    N*1/2(1535) FROM PI N TO N RHO,S=1/2,S-WAVE        SQRT(P1*P10)      11/75
R11  L      (+.12)OR  +.09         LONGACRE   75 IPWA   PI N TO 2PI N      11/75
R11 8       (+.10)                 LONGACRE   77 IPWA   PI N TO 2PI N      11/77

R12    N*1/2(1535) FROM PI N TO N EPSILON                 SQRT(P1*P4)       11/75
R12  L      (.1) OR  -.09          LONGACRE   75 IPWA   PI N TO 2PI N      11/75
R12 8       (-.08)                 LONGACRE   77 IPWA   PI N TO 2PI N      11/77

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            63  N*1/2(1535) PHOTON DECAY AMPL(GEV**-1/2)

     FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
   REVIEW PRECEDING THE BARYON LISTINGS.

A1     N*1/2(1535) INTO GAM P, HELICITY=1/2 (GEV**-1/2)
A1           .042      .023        DEVENISH  73 DPWA   PI N PHOTO PROD     2/74
A1          (.015)                 HEMMI1    73      + FWD PIO PHTOPROD    2/74
A1          +.053      .020        MOORHOUS  73 DPWA   PI N PHOTO-PROD     2/73
A1           .078      .020        DEVENIS2  74 DPWA   PI N PHOTO-PROD     4/75
A1           .056      .020        KNIES     74 DPWA   PI N PHOTO PROD     2/74
A1          +.063      .013        METCALF   74 DPWA   PI N PHOTO-PROD     2/74
A1           .036      .002        MOORHOUS  74 DPWA   PI N PHOTO-PROD     2/74
A1          +.082      .007        CRAWFORD  75 DPWA   PI N PHOTO-PROD     1/76
A1         (+.062)                 KRIVETS   75 DPWA   PI-N PHOTO-PROD     1/78
A1         (+.063)                 BARBOUR   76 DPWA   PI N PHOTO-PROD     1/76
A1          +.070      .004        FELLER    76 DPWA   PI N PHOTO-PROD     2/77
A1          +.046      .007        AZNAURYAN 77 DPWA   PIO PHTPRD,SOL 1 12/79*
A1          +.101      .012        AZNAURYAN 77 DPWA   PIO PHTPRD,SOL 2 12/79*
A1         (+.034)                 BERENDS   77 IPWA   PI-N PHOTO-PROD     1/78
A1   E      +.082      .019        BARBOUR   78 DPWA   PI-N PHOTO-PROD    3/79*
A1   N      (.046)                 NOELLE    78        PI-N PHOTO-PROD    1/80*
A1   N  CONVERTED TO OUR CONVENTIONS USING M=1.548, W=.073 FROM NOELLE 78.  1/80*
A1          . . . . . . . . . .
A1   AVERAGE MEANINGLESS (SCALE FACTOR = 4.7)

A2     N*1/2(1535) INTO GAM N, HELICITY=1/2 (GEV**-1/2)
A2          -.026      .029        DEVENISH  73 DPWA   PI N PHOTO PROD     2/74
A2          -.048      .021        MOORHOUS  73 DPWA   PI N PHOTO-PROD     2/73
A2 8        -.031      .024        ROSSI     73 DPWA 0 GAM N TO PI- P      4/75
A2 8    CONVERTED TO OUR CONVENTIONS USING M AND W FROM ROSSI73 AND X=.36   4/75
A2 9       (-.078)                 BENEVENT  74 DPWA 0 GAM N TO PI- P      4/75
A2 9    CCNVERTED TO OUR CONVENTIONS USING M=1520 MEV, W=80 MEV, X=.36      4/75
A2          -.037      .023        DEVENIS2  74 DPWA   PI N PHOTO-PROD     4/75
A2          -.052      .005        KNIES     74 DPWA   PI N PHOTO PROD     2/74
A2          -.051      .021        METCALF   74 DPWA   PI N PHOTO-PROD     2/74
A2          -.027      .009        MOORHOUS  74 DPWA   PI N PHOTO-PROD     2/74
A2          -.088      .011        CRAWFORD  75 DPWA   PI N PHOTO-PROD     1/76
A2         (-.109)                 BARBOUR   76 DPWA   PI N PHOTO-PROD     1/76
A2   E      -.112      .034        BARBOUR   78 DPWA   PI-N PHOTO-PROD    3/79*
A2   N     (-.048)                 NOELLE    78        PI-N PHOTO-PROD    1/80*
A2   N  CONVERTED TO OUR CONVENTIONS USING M=1.548, W=.073 FROM NOELLE 78.  1/80*
A2          . . . . . . . . . .
A2   AVERAGE MEANINGLESS (SCALE FACTOR = 1.7)

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REFERENCES FOR N*1/2(1535)


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HENDRY   65 PL 18 171          A W HENDRY, R G MOORHOUSE               (RHEL)
    REVIEWS EARLY PHASE-SHEFT-ANALYSIS RESULTS AND PI- P TO ETA N
    EXPERIMENTS. WE TAKE NUMBERS FROM THE SOLUTION USING BRANDSEN 65.
MICHAEL  66 PL 21 93           C MICHAEL                                (OXF)
UCHIYAMA 66 PR 149 1220        F UCHIYAMA-CAMPBELL, R K LOGAN       (ILL)IJP
DAVIES   67 NC 52A 1112        A T DAVIES, R G MOORHOUSE    (GLASGOW,RHEL)

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET    (SACLAY)IJP
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK           (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                            (EDIN)
DEANS    69 PR 185 1797        S DEANS, J WOOTEN          (UNIV S FLORIDA)
DELCOURT 69 PL 29B 75          DELCOURT,LEFRANCOIS,PEREZ-Y-JORBA,+  (ORSA)

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET          (SACL)IJP
CARRERAS 70 NP 16B 35          B CARRERAS, A DONNACHIE           (DARE,MCHS)
DAVIES   70 NP B21 359         A DAVIES                               (GLAS)
DIEM     70 KIEV CONF.         + SMADJA, CHAVANON, DELER, DOLBEAU+   (SACL)

ALMEHED  72 NP B40 157         +LOVELACE                      (LUND,RUTG)IJP
DEANS    72 PN 3 217           +JACOBS, LYONS, HICKS   (U S FL TAMPA+CARN)
DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH        (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+         (KYOTO+SAGA+KEK+TOKY)IJP
HICKS    73 PRD 7 2614         +DEANS,JACOBS,LYONS+ (CARN+ORNL+SOUTH FLA.)IJP
LEMOIGNE 73 PURDUE CONF. 93    +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK                (GLAS+LBL)IJP
ROSSI    73 NC 13A 59          +PIAZZA,SUSINNO,+     (ROMA,FRAS,NAPL,PAVIA)IJP
    ALSO 71 LNC 2 1183         CARBONARA, FIORE, +   (NAPL,FRAS,PAVIA,ROMA)IJP

BENEVENT 74 NC 19A 529         BENEVENTANO,DANGELO,NOTARISTEFANI,+  (RCMA)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN         (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680         KNIES,MOORHOUSE,OBERLACK          (LBL,GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                 (CIT)IJP
MOORHOUS 74 PRD 9 1            MOORHOUSE,OBERLACK,ROSENFELD      (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                          (GLAS)IJP
FELTESSE 75 NP B93 242         +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS  75 SJNP 20 430        +MIROSHNICHENKO,NIKIFOROV,SANIN+      (KIEV)IJP
    ALSO 74 SJNP 19 112        KRIVETS,NIKIFOROV,SANIN,SHALATSKII    (KIEV)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+       (LBL,SLAC)IJP
    ALSO 78 PRD 17 1795        LONGACRE,LASINSKI,ROSENFELD+      (LBL,SLAC)

AYED     76 CEA-N-1921         AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358        I. M. BARBOUR,R. L. CRAWFORD          (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP

AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
BERENDS  77 NP B136 317        F.A.BERENDS,A.DONNACHIE           (LEID,MCHS)IJP
BHANDARI 77 PRD 15 192         R BHANDARI,Y-A CHAO                   (CARN)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                      (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP

BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS              (GLAS)
NOELLE   78 PTP 60 778         P. NOELLE                             (NAGO)
BAKER    79 NP B156 93         +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+   (RHEL)IJP
CUTKOSKY 79 PRD 20 2839        +FORSYTH,HENDRICK,KELLY           (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN          /KARLSRUHE IJP
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Baryons
N(1535), N(1540), N(1650)

Data Card Listings
For notation, see key at front of Listings.

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                        PAPERS NOT REFERRED TO IN DATA CARDS

BAREYRE  65 PL 18 342           + BRICMAN, STIRLING, VILLET        (SACLAY)IJP
BRANDSEN 65 PR 139 B1566        +ODONNELL, MOORHOUSE          (DURHAM, RHEL)IJP
   BASIS OF NUMBERS WE QUOTE FROM HENDRY 65.
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                             (LRL)
LOVELACE 67 HEIDELBERG C. 79  C LOVELACE                            (CERN)IJP
DONNACHI 69 NP 10B 433          A DONNACHIE, R KIRSOPP              (GLAS+EDIN)
AYED     70 PL 31B 598          +BAREYRE+VILLET                      (SACLAY)

       THE FOLLOWING ARTICLES DEAL WITH THE REACTIONS PI- P TO ETA N
    AND GAMMA P TO ETA P NEAR THRESHOLD. THE DATA AND THE THEORETICAL
    ARTICLES ARE USEFUL IN UNDERSTANDING THE BEHAVIOR OF THE S11 AMPLI-
    TUDE AS DETERMINED IN PI P PHASE-SHIFT ANALYSES. FURTHER REFERENCES
    MAY BE FOUND IN THEM.

     MAINLY EXPERIMENTAL --
BULOS    64 PRL 13 486          +        (BROWN,BRANDEIS,HARVARD,MIT,PADOVA) I
BACCI    66 NC 45A 983          +PENSO,SALVINI,MENCUCCINI,+ (ROMA,FRASCATI)IJP
JONES    66 PL 23 597           +BINNIE,DUANE,HORSEY,MASON,+     (LOIC,RHEL)
RICHARDS 66 PRL 16 1221         +CHIU,EANDI,HELMHOLZ,KENNEY,+  (LRL,HAWAII) IJ
PREPOST  67 PRL 18 82           R PREPOST, D LUNDQUIST, D QUINN  (STANFORD)
BLOCM    68 PRL 21 1100         +HEUSCH, PRESCOTT, ROCHESTER           (CIT)
BULOS    69 PR 187 1827         +LANOU,BORDNER,BASTIEN+(BOST+HARV+MIT+PENN)
HEUSCH   70 PRL 25 1381         +PRESCOTT,ROCHESTER,WINSTEIN           (CIT)
BINNIE   73 PRD 8 2789          +CAMILLERI,DEBENHAM,DUANE,+      (LOIC,SHMP)
     MAINLY THEORETICAL --
BALL     66 PR 149 1191         J S BALL                              (UCLA)
DOBSON   66 PR 146 1022         P N DOBSON                          (HAWAII)
MINAMI   66 PR 147 1123         S MINAMI                             (OSAKA)
DEANS    67 PR 161 1466         S R DEANS, W G HOLLADAY        (VANDERBILT)
LOGAN    67 PR 153 1634         R K LOGAN, F UCHIYAMA-CAMPBELL         (ILL)
MENCUCCI 67 NC 48A 579          C MENCUCCINI, A REALE             (FRASCATI)
MINAMI   67 PR 162 1619         S MINAMI                             (OSAKA)
MOSS     67 PR 163 1785         T A MOSS                               (LSU)
DEANS    68 PR 165 1886         S R DEANS, W G HOLLADAY        (VANDERBILT)
PAL      68 PR 167 1350         B K PAL                      (NPL NEW DELHI)
BALL     69 PR 177 2257         +GARG+SHAW                        (UCLA+UCI)
LEFIEVRE 70 NC 66A 349          +LERUSTE                              (CDEF)

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N(1540) 109 N*1/2(1540, JP=3/2+) I=1/2 **P'_{13}** 11/77

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              109  N*1/2(1540) MASS (MEV)                              11/77

M  8    (1540.)                   LONGACRE  77 IPWA    PI N TO 2PI N   11/77
M  8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M  8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                     11/77

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              109  N*1/2(1540) WIDTH (MEV)                             11/77

W  8     (200.)                   LONGACRE  77 IPWA    PI N TO 2PI N   11/77

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              109  N*1/2(1540) REAL PART OF POLE POSITION (MEV)        11/77

RE  8     1535. OR 1482.          LONGACRE  77 IPWA    PI N TO 2PI N   11/77

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              109  N*1/2(1540) -2*IMAG PART OF POLE POSITION (MEV)     11/77

IM  8     207. OR 314.            LONGACRE  77 IPWA    PI N TO 2PI N   11/77

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              109  N*1/2(1540) PARTIAL DECAY MODES                     11/77

                                                     DECAY MASSES
P1     N*1/2(1540) INTO PI N                         139+ 938
P2     N*1/2(1540) INTO N RHO,S=1/2,P-WAVE           938+ 776
P3     N*1/2(1540) INTO N RHO,S=3/2,P-WAVE           938+ 776
P4     N*1/2(1540) INTO N*3/2(1232) PI,P-WAVE        1232+ 139
P5     N*1/2(1540) INTO N EPSILON                    938+1300

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              109  N*1/2(1540) BRANCHING RATIOS                        11/77

R1     N*1/2(1540) FROM PI N TO N RHO,S=1/2,P-WAVE      SQRT(P1*P2)    11/77
R1  8       (-.08)                LONGACRE  77 IPWA    PI N TO 2PI N   11/77

R2     N*1/2(1540) FROM PI N TO N RHO,S=3/2,P-WAVE      SQRT(P1*P3)    11/77
R2  8       (.00)                 LONGACRE  77 IPWA    PI N TO 2PI N   11/77

R3     N*1/2(1540) FROM PI N TO N*3/2(1232) PI,P-WAVE   SQRT(P1*P4)    11/77
R3  8       (+.11)                LONGACRE  77 IPWA    PI N TO 2PI N   11/77

R4     N*1/2(1540) FROM PI N TO N EPSILON               SQRT(P1*P5)    11/77
R4  8       (.00)                 LONGACRE  77 IPWA    PI N TO 2PI N   11/77

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                        REFERENCES FOR N*1/2(1540)

LONGACRE 77 NP B122 493         LONGACRE,DOLBEAU                    (SACL)IJP
   ALSO  76 NP B108 365         DOLBEAU,TRIANTIS,NEVEU,CADIET       (SACL)IJP

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N(1650) 66 N*1/2(1650, JP=1/2-) I=1/2 **S''_{11}**

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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              66  N*1/2(1650) MASS (MEV)

M       (1695.0)                  BRANDSEN  65 RVUE    PHASE-SHIFT ANAL  9/66
M       (1700.0)                  MICHAEL   66 RVUE    FITS BAREYRE S11  7/66
M  G    (1710.0)                  BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M  G         WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M  3    (1710.0)                  DONNACH1  68 RVUE    PHASE-SHIFT ANAL  8/68
M       (1705.0)    (10.0)        ORITO     69 RVUE    K LAMBDA PS ANAL  8/69
M  6    (1689.0)                  AYED      70 IPWA                      1/71
M  6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M  4    (1766.0)                  DAVIES    70 RVUE    P-S ANAL   SOL A  8/69
M       (1678.0)                  SCHORSCH  70 DPWA    K LAM PHOTOPRO.  10/71
M  A    (1685.0)                  WAGNER    71 IPWA    PI-P TO K LAMB    1/71
M  A  THERE ARE 3 SIMILAR SOLUTIONS
M  7    (1670.)                   ALMEHED   72 IPWA                      2/72
M   2   (1699.)                   HICKS     73 MPWA    GAM P-ETA P       9/73
M   2  CNLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS.   9/73
M   2  M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII.  9/73
M   1   (1860.)                   LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
M   1  S11 AMPLITUDE LARGE BUT NOT RESONANT IN SOLUTION 1 OF LANGBEIN73  9/73
M   1  DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF   1/78
M   1  WINNIK77 AROUND 1920 MEV.                                         1/78
M       (1675.)                   KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
M   L     1675. OR 1660.          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M   L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75. 11/75
M       (1673.)                   AYED      76 IPWA                     11/77
M       (1676.)                   BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
M  D    (1700.)      (5.)         BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
M  E    (1680.)                   BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
M  D   THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET   1/78
M  E   ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.         1/78
M  8    (1700.)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M  8   ALL LCNGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M  8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                      11/77
M       (1680.)                   BAKER     78 DPWA  0 PI- P TO K LAM   3/79*
M   9   (1694.)                   BARBOUR   78 DPWA    PI-N PHOTO-PROD  3/79*
M   9  SUPERSEDES BARBOUR 76.                                           3/79*
M         1640.      30.          CUTKOSKY  79 IPWA    PI N TO PI N    12/79*
M         1670.       8.          HOEHLER   79 IPWA    PI N TO PI N    12/79*
M  H    (1680.)                   SAXON     80 DPWA  0 PI- P TO K LAM  12/79*
M       . . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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              66  N*1/2(1650) WIDTH (MEV)

W         (240.0)                 MICHAEL   66 RVUE                      7/66
W  1      (260.0)                 BAREYRE   68 RVUE                     11/67
W  3      (300.0)                 DONNACH1  68 RVUE                      8/69
W         (104.0)    (15.0)       ORITO     69 RVUE                      8/69
W  6      (166.0)                 AYED      70 IPWA                      1/71
W  4      (404.0)                 DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
W  4   SOL B GIVES 121 MEV                                               2/73
W          (99.0)                 SCHORSCH  70 DPWA    K LAM PHOTOPRO.  10/71
W  A      (110.0)OR(140.0)        WAGNER    71 IPWA    PI-P TO K LAMB    1/71
W  7      (120.)                  ALMEHED   72 IPWA                      2/72
W   2     (195.)                  HICKS     73 MPWA    GAM P-ETA P       9/73
W   1     (200.)                  LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
W         (170.)                  KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
W   L      150. OR  130.          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W         (150.)                  AYED      76 IPWA                     11/77
W         (194.)                  BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
W  D      (130.)     (10.)        BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
W  E       (90.)                  BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
W  8      (170.)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W          (90.)                  BAKER     78 DPWA  0 PI- P TO K LAM   3/79*
W   9     (193.)                  BARBOUR   78 DPWA    PI-N PHOTO-PROD  3/79*
W          140.       40.         CUTKOSKY  79 IPWA    PI N TO PI N    12/79*
W          180.       20.         HOEHLER   79 IPWA    PI N TO PI N    12/79*
W  H      (120.)                  SAXON     80 DPWA  0 PI- P TO K LAM  12/79*
W       . . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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              66  N*1/2(1650) REAL PART OF POLE POSITION (MEV)         11/75

RE        (1648.)                 LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE  8      1699. OR 1698.         LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE        (1639.)                 CUTKOSKY  79 IPWA    PI N TO PI N    12/79*

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              66  N*1/2(1650) -2*IMAG PART OF POLE POSITION (MEV)      11/75

IM        (117.)                  LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM  8      174. OR 173.           LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM        (140.)                  CUTKOSKY  79 IPWA    PI N TO PI N    12/79*

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              66  N*1/2(1650) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER         (3.)                  CUTKOSKY  79 IPWA    PI N TO PI N    12/79*

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              66  N*1/2(1650) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR       (-58.)                  CUTKOSKY  79 IPWA    PI N TO PI N    12/79*

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              66  N*1/2(1650) PARTIAL DECAY MODES

                                                     DECAY MASSES
P1     N*1/2(1650) INTO PI N                         139+ 938
P2     N*1/2(1650) INTO N ETA                        939+ 548
P3     N*1/2(1650) INTO LAMBDA K                     1115+ 497
P4     N*1/2(1650) INTO GAM P, HELICITY=1/2            0+ 938
P5     N*1/2(1650) INTO GAM N, HELICITY=1/2            0+ 939
P6     N*1/2(1650) INTO N PI PI                      938+ 139+ 139
P7     N*1/2(1650) INTO N EPSILON                    938+1300
P8     N*1/2(1650) INTO N RHO                        938+ 776
P9     N*1/2(1650) INTO K SIGMA                      493+1189
P10    N*1/2(1650) INTO N RHO,S=1/2,S-WAVE           938+ 776
P11    N*1/2(1650) INTO N RHO,S=3/2,D-WAVE           938+ 776
P12    N*1/2(1650) INTO N*3/2(1232) PI               1232+ 139

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Data Card Listings

For notation, see key at front of Listings.

Baryons

N(1650), N(1670)

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                66  N*1/2(1650) BRANCHING RATIOS

R1       N*1/2(1650) INTO (PI N)/TOTAL                              (P1)
R1           (1.0)         APPROX         MICHAEL    66 RVUE                            7/66
R1   3       (0.79)                       DONNACH1   68 RVUE                            8/69
R1   6       (0.642)                      AYED       70 IPWA                            1/71
R1   4       (0.56)                       DAVIES     70 RVUE      P-S ANAL   SOL A      8/69
R1   7       (0.5)                        ALMEHED    72 IPWA                            2/72
R1           (.54)                        AYED       76 IPWA                           11/77
R1            .60        .05              CUTKOSKY   79 IPWA      PI N TO PI N         12/79*
R1            .61        .04              HOEHLER    79 IPWA      PI N TO PI N         12/79*
R1          . . . . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R2       N*1/2(1650) FROM PI N TO K LAMBDA                    SQRT(P1*P3)               4/75
R2           (.20)    (.05)               ORITO      69 RVUE                            4/75
R2   A       (.21)OR .23                  WAGNER     71 IPWA      PI- P TO K LAMB       4/75
R2           -.179       .033             DEVENISH   74         0 FIXED T DISP REL      4/75
R2           (.12)                        KNASEL     75 DPWA    O PI- P TO KO LAM      11/75
R2   D       (-.23)   (.01)               BAKER      77 IPWA    O PI- P TO K LAM.       1/78
R2   E       (-.25)                       BAKER      77 DPWA    O PI- P TO K LAM.       1/78
R2   F       (-.25)                       BAKER      78 DPWA    O PI- P TO K LAM        3/79*
R2   F   THE (UNDETERMINED) OVERALL PHASE OF ALL COUPLINGS FROM BAKER78                 3/79*
R2   F   HAS BEEN CHANGED TO AGREE WITH PREVIOUS CONVENTIONS.                           3/79*
R2   H       (-.22)                       SAXON      80 DPWA    O PI- P TO K LAM       12/79*
R2   H   SUPERSEDES BAKER 78.                                                          12/79*

R3       N*1/2(1650) INTO (LAMBDA K)/TOTAL                          (P3)
R3   B       (0.028)       APPROX.        RUSH       68 MPWA      T POLE + RESON.       8/69
R3   B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R4       N*1/2(1650) INTO (N ETA)/TOTAL                             (P2)
R4   B       (0.013)                      BOTKE      69 MPWA      T POLE + RESON.      10/69
R4   B       (0.03)     (0.02)            DEANS      69 MPWA      T POLE + RESON.       8/69
R4   C       (0.19) OR 0.27               CARRERAS   70 MPWA      T POLE + RESON.       5/70
R4   B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING
R4   C   CARRERAS 70 USES REGGE POLES + RESONANCES. VALUES SUSPICIOUSLY LARG

R5       N*1/2(1650) FROM GAMMA PROTON TO K LAMBDA            SQRT(P3*P4)               9/73
R5           (0.002)OR LESS               ORITO2     69 CNTR      K LAM PHOTOPRO       10/71
R5           (0.0072)                     SCHORSCH   70 DPWA      K LAM PHOTOPRO.      10/71
R5           (.0060)                      DEANS      72 MPWA      GAM P-K LM,SOL D      9/73

R6       N*1/2(1650) FROM GAMMA PROTON TO ETA PROTON          SQRT(P2*P4)               9/73
R6   2       (.0101)                      HICKS      73 MPWA      GAM P-ETA P           9/73

R7       N*1/2(1650) FROM PI N TO K SIGMA                     SQRT(P1*P9)               9/73
R7   1       (.11)                        LANGBEIN   73 IPWA      PI N-K SIG,SOL 2      9/73
R7   5       (.066)TO  .137               DEANS      75 DPWA      PI N TO K SIGMA      11/75
R7   5   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                                      11/75
R7           (.20)                        KNASEL     75 DPWA    O PI- P TO KO LAM      11/75

R8       N*1/2(1650) FROM PI N TO N*3/2(1232) PI              SQRT(P1*P12)             11/75
R8   L       (-.16)OR  -.15               LONGACRE   75 IPWA      PI N TO 2PI N        11/75
R8   8       (-.29)                       LONGACRE   77 IPWA      PI N TO 2PI N        11/77
R8   8   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R9       N*1/2(1650) FROM PI N TO N RHO,S=1/2,S-WAVE          SQRT(P1*P10)             11/75
R9   L       (.23)OR  +.16                LONGACRE   75 IPWA      PI N TO 2PI N        11/75
R9   8       (-.17)                       LONGACRE   77 IPWA      PI N TO 2PI N        11/77

R10      N*1/2(1650) FROM PI N TO N RHO,S=3/2,D-WAVE          SQRT(P1*P11)             11/77
R10  8       (-.29)                       LONGACRE   77 IPWA      PI N TO 2PI N        11/77
R10  8   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R11      N*1/2(1650) FROM PI N TO N EPSILON                   SQRT(P1*P7)              11/75
R11  L       (-.23)OR  -.25               LONGACRE   75 IPWA      PI N TO 2PI N        11/75
R11  8       (.00)                        LONGACRE   77 IPWA      PI N TO 2PI N        11/77

R12      N*1/2(1650) FROM PI N TO ETA N                       SQRT(P1*P2)              12/79*
R12  I       (-.09)                       BAKER      79 DPWA    O PI- P TO ETA N       12/79*
R12  I   THIS COUPLING WAS FIXED DURING FITTING, BUT THE NEGATIVE SIGN                 12/79*
R12  I   RELATIVE TO N(1535) IS WELL DETERMINED.                                       12/79*
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                66  N*1/2(1650) PHOTON DECAY AMPL(GEV**-1/2)

     FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
   REVIEW PRECEDING THE BARYON LISTINGS.

A1       N*1/2(1650) INTO GAM P, HELICITY=1/2 (GEV**-1/2)
A1            .024      .033              DEVENISH   73 DPWA      PI N PHOTO PROD       2/74
A1           +.066      .042              MOORHOUS   73 DPWA      PI N PHOTO-PROD       2/73
A1            .029      .018              DEVENIS2   74 DPWA      PI N PHOTO-PROD       4/75
A1            .058      .018              KNIES      74 DPWA      PI N PHOTO PROD       2/74
A1           +.012      .015              METCALF    74 DPWA      PI N PHOTO-PROD       2/74
A1            .054      .005              MOORHOUS   74 DPWA      PI N PHOTO-PROD       2/74
A1           +.044      .018              CRAWFORD   75 DPWA      PI N PHOTO-PROD       1/76
A1           (+.044)                      BARBOUR    76 DPWA      PI N PHOTO-PROD       1/76
A1           +.068      .009              FELLER     76 DPWA      PI N PHOTO-PROD       2/77
A1           +.004      .004              AZNAURYAN  77 DPWA      PIO PHTPRD,SOL 1     12/79*
A1           +.003      .004              AZNAURYAN  77 DPWA      PIO PHTPRD,SOL 2     12/79*
A1   9       +.048      .017              BARBOUR    78 DPWA      PI-N PHOTO-PROD       3/79*
A1          . . . . . . . . .
A1   AVERAGE MEANINGLESS (SCALE FACTOR = 3.8)

A2       N*1/2(1650) INTO GAM N, HELICITY=1/2 (GEV**-1/2)
A2            .010      .043              DEVENISH   73 DPWA      PI N PHOTO PROD       2/74
A2           -.072      .066              MOORHOUS   73 DPWA      PI N PHOTO-PROD       2/73
A2           -.006      .031              DEVENIS2   74 DPWA      PI N PHOTO-PROD       4/75
A2           -.015      .035              KNIES      74 DPWA      PI N PHOTO PROD       2/74
A2           -.019      .022              METCALF    74 DPWA      PI N PHOTO-PROD       2/74
A2           -.027      .009              MOORHOUS   74 DPWA      PI N PHOTO-PROD       2/74
A2           -.103      .010              CRAWFORD   75 DPWA      PI N PHOTO-PROD       1/76
A2           (-.022)                      BARBOUR    76 DPWA      PI N PHOTO-PROD       1/76
A2   9       -.045      .024              BARBOUR    78 DPWA      PI-N PHOTO-PROD       3/79*
A2          . . . . . . . . .
A2   AVERAGE MEANINGLESS (SCALE FACTOR = 2.6)

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                         REFERENCES FOR N*1/2(1650)
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BRANDSEN 65 PL 19 420         +ODONNELL, MOORHOUSE              (DURHAM, RHEL)IJP

MICHAEL  66 PL 21 93          C MICHAEL                                    (OXF)

BAREYRE  68 PR 165 1731       P BAREYRE, C BRICMAN, G VILLET         (SACLAY)IJP
DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
   ALSO  68 VIENNA 139        DONNACHIE  RAPPORTEUR.S TALK                (GLAS)
   ALSO  68 THESIS            R G KIRSOPP                                 (EDIN)
RUSH     68 PR 173 1776       J E RUSH                             (UNIV ALABAMA)

BOTKE    69 PR 180 1417       J C BOTKE                                   (UCSB)
DEANS    69 PR 185 1797       S DEANS, J WOOTEN                 (UNIV S FLORIDA)
ORITO    69 LNC 1 936         S ORITO,S SASAKI                    (TOKYO-OSAKA)
ORITO2   69 INS J 113         S ORITO (THESIS)                           (TOKYO)

AYED     70 KIEV CONF         R AYED,P BAREYRE, G VILLET              (SACL)IJP
CARRERAS 70 NP 16B 35         B CARRERAS, A DONNACHIE             (DARE,MCHS)
DAVIES   70 NP B21 359        A DAVIES                                    (GLAS)
SCHORSCH 70 NP  B25 179       +TIETGE,HEILNBOECK                          (MPIM)

WAGNER   71 NP B25 411        F WAGNER, C LOVELACE                        (CERN)

ALMEHED  72 NP B40 157        +LOVELACE                           (LUND,RUTG)IJP
DEANS    72 PRD 6 1906        DEANS,JACOBS, LYONS,MONTGOMERY (SOUTH FLA.)IJP
DEVENISH 73 PL 47B 53         DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
HICKS    73 PRD 7 2614        +DEANS,JACOBS,LYONS+ (CARN+ORNL+SOUTH FLA.)IJP
LANGBEIN 73 NP B53 251        LANGBEIN,WAGNER                        (MUNICH)IJP
MOORHOUS 73 PL 43B 44         MOORHOUSE, OBERLACK                  (GLAS+LBL)IJP

DEVENISH 74 NP B81 330        DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2 74 PL 52B 227        DEVENISH,LYTH,RANKIN          (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680        KNIES,MOORHOUSE,OBERLACK            (LBL,GLAS)IJP
METCALF  74 NP B76 253        W J METCALF,R L WALKER                   (CIT)IJP
MOORHOUS 74 PRD 9 1           MOORHOUSE,OBERLACK,ROSENFELD        (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125        R L CRAWFORD                            (GLAS)IJP
DEANS    75 NP B96 90         +MITCHELL,MONTGOMERY,+          (SFLA,ALABAMA)IJP
KNASEL   75 PRD 11 1          +LINDQUIST,NELSON+      (CHIC,WUSL,OSU,ANL)IJP
LONGACRE 75 PL 55B 415        +ROSENFELD,LASINSKI,SMADJA+         (LBL,SLAC)IJP
   ALSO  78 PRD 17 1795       LONGACRE,LASINSKI,ROSENFELD+          (LBL,SLAC)

AYED     76 CEA-N-1921        AYED (THESIS)                           (SACL)IJP
BARBOUR  76 NP B111 358       I. M. BARBOUR,R. L. CRAWFORD            (GLAS)IJP
FELLER   76 NP B104 219       +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP

AZNAURYA 77  EFI-264(57)-77   +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
BAKER    77 NP B126 365       +BLISSET,BLOODWORTH,BROCME,HART+        (RHEL)IJP
LONGACRE 77 NP B122 493       LONGACRE,DOLBEAU                        (SACL)IJP
   ALSO  76 NP B108 365       DOLBEAU,TRIANTIS,NEVEU,CADIET           (SACL)IJP

BAKER    78 NP B141 29        +BLISSET,BLOODWORTH,BROCME+         (RL+CAMB)IJP
BARBOUR  78 NP B141 253       BARBOUR,CRAWFORD,PARSONS                    (GLAS)
BAKER    79 NP B156 93        +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+   (RHEL)IJP
CUTKOSKY 79 PRD 20 2839       +FORSYTH,HENDRICK,KELLY             (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN             /KARLSRUHE IJP
SAXON    80 NP B162 522       +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS

BAREYRE  65 PL 18 342         + BRICMAN, STIRLING, VILLET           (SACLAY)IJP
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                                  (LRL)
DEANS    69 PR  177 2623      S R DEANS                         (UNIV S FLORIDA)
DONNACHI 69 NP 10B 433        A DONNACHIE, R KIRSOPP               (GLAS+EDIN)
AYED     70 PL 31B 598        +BAREYRE+VILLET                           (SACLAY)
WINNIK   77 NP B128 66        +TOAFF,REVEL,GOLDBERG,BERNY                (HAIF)I
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N(1670)   64 N*1/2(1670, JP=5/2-) I=1/2 D'_{15}

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        THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                64  N*1/2(1670) MASS (MEV)

M         (1650.0)         APPROX        BRANDSEN   65 RVUE    PHASE-SHIFT ANAL  7/66
M    1    (1680.0)                       BAREYRE    68 RVUE    PHASE-SHIFT ANAL 11/67
M    1            WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    3    (1678.0)                       DONNACH1   68 RVUE    PHASE-SHIFT ANAL  6/68
M         (1674.0)                       DUKE       68 CNTR    PI-P EL + POL     6/68
M    6    (1675.0)                       AYED       70 IPWA                      1/71
M    6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M    4    (1669.0)                       DAVIES     70 RVUE    P-S ANAL   SOL A  8/69
M    7    (1683.)                        ALMEHED    72 IPWA                      2/72
M          1652. TO 1687.                CRAWFORD   75 DPWA    PI N PHOTO-PROD   1/76
M    L     1660. OR 1660.                LONGACRE   75 IPWA    PI N TO 2PI N    11/75
M    L   THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.     11/75
M         (1660.)                        AYED       76 IPWA                     11/77
M         (1687.)                        BARBOUR    76 DPWA    PI N PHOTO-PROD   1/76
M    8    (1650.)                        LONGACRE   77 IPWA    PI N TO 2PI N    11/77
M    8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                            11/77
M    5    (1680.)                        BARBOUR    78 DPWA    PI-N PHOTO-PROD   3/79*
M    5   SUPERSEDES BARBOUR 76.                                                  3/79*
M          1680.       15.               CUTKOSKY   79 IPWA    PI N TO PI N     12/79*
M          1679.        8.               HOEHLER    79 IPWA    PI N TO PI N     12/79*
M    9    (1670.)                        SAXON      80 DPWA  O PI- P TO K LAM   12/79*
M         . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
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                64  N*1/2(1670) WIDTH (MEV)

W    1    (135.0)                        BAREYRE    68 RVUE                     11/67
W    3    (173.0)                        DONNACH1   68 RVUE                      6/68
W    6    (143.0)                        AYED       70 IPWA                      1/71
W    4    (115.0)                        DAVIES     70 RVUE    SOL A AND B       8/69
W    7    (150.)                         ALMEHED    72 IPWA                      2/72
W          165. TO  185.                 CRAWFORD   75 DPWA    PI N PHOTO-PROD   1/76
W    L     145. OR  150.                 LONGACRE   75 IPWA    PI N TO 2PI N    11/75
W         (146.)                         AYED       76 IPWA                     11/77
W         (172.)                         BARBOUR    76 DPWA    PI N PHOTO-PROD   1/76
W    8    (130.)                         LONGACRE   77 IPWA    PI N TO 2PI N    11/77
W    5    (192.)                         BARBOUR    78 DPWA    PI-N PHOTO-PROD   3/79*
W          (88.)                         BAKER      79 DPWA  O PI- P TO ETA N   12/79*
W          180.        30.               CUTKOSKY   79 IPWA    PI N TO PI N     12/79*
W          120.        15.               HOEHLER    79 IPWA    PI N TO PI N     12/79*
W    9     (40.)                         SAXON      80 DPWA  O PI- P TO K LAM   12/79*
W         . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.8)
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
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                64  N*1/2(1670) REAL PART OF POLE POSITION (MEV)          11/75

RE        (1663.)                        LONGACRE   75 IPWA    PI N TO 2PI N    11/75
RE   8     1649. OR 1650.                LONGACRE   77 IPWA    PI N TO 2PI N    11/77
RE        (1663.)                        CUTKOSKY   79 IPWA    PI N TO PI N     12/79*
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Baryons
N(1670)

Data Card Listings
For notation, see key at front of Listings.

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                    64  N*1/2(1670) -2*IMAG PART OF POLE POSITION (MEV)      11/75

IM          (146.)                    LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   8       127. OR 127.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM          (150.)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                    64  N*1/2(1670) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER         (33.)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                    64  N*1/2(1670) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         (-11.)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                    64  N*1/2(1670) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1      N*1/2(1670) INTO PI N                         139+ 938
P2      N*1/2(1670) INTO N ETA                        939+ 548
P3      N*1/2(1670) INTO LAMBDA K                    1115+ 497
P4      N*1/2(1670) INTO N*3/2(1232) PI              1232+ 139
P5      N*1/2(1670) INTO N PI PI                      938+ 139+ 139
P6      N*1/2(1670) INTO GAM P, HELICITY=1/2            0+ 938
P7      N*1/2(1670) INTO GAM P, HELICITY=3/2            0+ 938
P8      N*1/2(1670) INTO GAM N, HELICITY=1/2            0+ 939
P9      N*1/2(1670) INTO GAM N, HELICITY=3/2            0+ 939
P10     N*1/2(1670) INTO SIGMA K                      493+1189
P11     N*1/2(1670) INTO N*3/2(1232) PI,D-WAVE       1232+ 139
P12     N*1/2(1670) INTO N RHO,S=3/2,D-WAVE           938+ 776
P13     N*1/2(1670) INTO N EPSILON                    938+1300

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                    64  N*1/2(1670) BRANCHING RATIOS

R1      N*1/2(1670) INTO (PI N)/TOTAL                          (P1)
R1  1          (0.41)                 BAREYRE   68 RVUE                     11/67
R1  3          (0.391)                DONNACH1  68 RVUE                      6/68
R1  6          (0.392)                AYED      70 IPWA                      1/71
R1  4          (0.50)                 DAVIES    70 RVUE    P-S ANAL   SOL A  8/69
R1  7          (0.45)                 ALMEHED   72 IPWA                      2/72
R1              (.41)                 AYED      76 IPWA                     11/77
R1               .35      .06         CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
R1               .38      .03         HOEHLER   79 IPWA    PI N TO PI N     12/79*
R1            . . . . . . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

R2      N*1/2(1670) INTO (N ETA)/TOTAL                         (P2)
R2             (0.02) OR LESS         TRIPP     67 RVUE                      8/67
R2  B          (0.018)                BOTKE     69 MPWA    T POLE + RESON.  10/69
R2  B          (0.006)  (0.004)       DEANS     69 MPWA    T POLE + RESON.   5/70
R2  B          (0.006)OR 0.012        CARRERAS  70 MPWA    T POLE + RESON.   5/70
R2  B    PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R3      N*1/2(1670) INTO (LAMBDA K)/TOTAL                      (P3)
R3             (0.016)OR LESS         TRIPP     67 RVUE                      8/67
R3  B          (0.001)OR LESS         RUSH      68 MPWA    T POLE + RESON.   8/69
R3  B    PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING
R3             (0.0028)OR LESS CL=.63 WAGNER    71 IPWA    PI-P TO K LAMB    1/71

R4      N*1/2(1670) INTO (N*3/2(1232) PI)/TOTAL                (P4)
R4 E 12600     0.63      0.1          BRODY     71  HBC    PI-P--2PI N,PWA   6/70
R4 E         ASSUMES ELASTIC BRANCHING RATIO 0.42+-0.04

R5      N*1/2(1670) FRCM PI N TO K LAMBDA                     SQRT(P1*P3)        4/75
R5             -.034     .006         DEVENISH  74         0 FIXED T DISP REL  4/75
R5       COUPLING TO LAMBDA K NOT REQUIRED IN THE ANALYSES OF BAKER77 AND    3/79*
R5       BAKER78.                                                             3/79*
R5  9          (+.036)                SAXON     80 DPWA  0 PI- P TO K LAM   12/79*
R5  9    SUPERSEDES BAKER 78.  COUPLING PHASE IS NEAR 90 DEGREES.            12/79*

R6      N*1/2(1670) FROM PI N TO ETA N                        SQRT(P1*P2)        11/75
R6  2          (0.0)OR  (+.009)       FELTESSE  75 DPWA  0 1488 TO 1745 MEV 11/75
R6  2    USES M AND W OF AYED 76.                                            11/75
R6             (-.07)                 BAKER     79 DPWA  0 PI- P TO ETA N   12/79*

R7      N*1/2(1670) FROM PI N TO K SIGMA                      SQRT(P1*P10)       11/75
R7  2       LESS THAN .003            DEANS     75 DPWA    PI N TO K SIGMA  11/75
R7  2    RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                            11/75
R7  2    DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77           1/78
R7  2    AROUND 1920 MEV.                                                     1/78

R8      N*1/2(1670) FROM PI N TO N*3/2(1232) PI,D-WAVE   SQRT(P1*P11)       11/75
R8   L         (-.45)OR  -.50         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R8  8          (-.46)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R8  8    LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R8   N         (-.5)                  NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79*
R8   N   BW FIT TO LONGACRE 75 IPWA.                                          3/79*

R9      N*1/2(1670) FROM PI N INTO N RHO,S=3/2,D-WAVE    SQRT(P1*P12)       11/77
R9  8          (+.15)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R9  8    LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R10     N*1/2(1670) FROM PI N INTO N EPSILON                  SQRT(P1*P13)       11/77
R10 8          (-.03)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77

   SEE NCTE PRECEDING THE N*1/2(1688) INELASTIC DECAY MODE MEASUREMENTS.

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                    64  N*1/2(1670) PHOTON DECAY AMPL(GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*1/2(1670) INTO GAM P, HELICITY=1/2  (GEV**-1/2)
A1             .027      .030         DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A1            (.023)                  HEMMI1    73       + FWD PIO PHTOPROD  2/74
A1            +.011      .012         MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A1             .019      .021         DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A1             .013      .014         KNIES     74 DPWA    PI N PHOTO PROD   2/74
A1            +.010      .013         METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A1             .019      .007         MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A1            +.027      .009         CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A1           (+.004)                  KRIVETS   75 DPWA    PI-N PHOTO-PROD   1/78
A1           (+.008)                  BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A1            +.034      .004         FELLER    76 DPWA    PI N PHOTO-PROD   2/77
A1            +.034      .003         AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79*
A1            +.071      .002         AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79*
A1  5         +.022      .010         BARBOUR   78 DPWA.   PI-N PHOTO-PROD   3/79*
A1            . . . . . . . . . . .
A1   AVERAGE MEANINGLESS (SCALE FACTOR = 5.2)

A2      N*1/2(1670) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2             .036      .030         DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A2            +.021      .020         MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A2             .014      .004         DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A2             .014      .008         KNIES     74 DPWA    PI N PHOTO PROD   2/74
A2            +.042      .024         METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A2             .016      .002         MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A2            +.015      .006         CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A2           (+.021)                  KRIVETS   75 DPWA    PI-N PHOTO-PROD   1/78
A2           (+.021)                  BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A2            +.019      .009         FELLER    76 DPWA    PI N PHOTO-PROD   2/77
A2            +.010      .010         AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79*
A2            +.002      .021         AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79*
A2  5         +.015      .006         BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A2            . . . . . . . . . . .
A2   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

A3      N*1/2(1670) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3            -.060      .062         DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A3            +.010      .040         MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A3            -.029      .023         DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A3            -.043      .006         KNIES     74 DPWA    PI N PHOTO PROD   2/74
A3             .004      .015         METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A3            -.017      .004         MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A3            -.052      .003         CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A3           (-.058)                  BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A3  5         -.066      .020         BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A3            . . . . . . . . . . .
A3   AVERAGE MEANINGLESS (SCALE FACTOR = 4.4)

A4      N*1/2(1670) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4            -.072      .022         DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A4            -.035      .014         MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A4            -.068      .020         DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A4            -.071      .030         KNIES     74 DPWA    PI N PHOTO PROD   2/74
A4            -.009      .029         METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A4            -.049      .004         MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A4            -.083      .007         CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A4           (-.080)                  BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A4  5         -.073      .014         BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A4            . . . . . . . . . . .
A4   AVERAGE MEANINGLESS (SCALE FACTOR = 2.1)

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                              REFERENCES FOR N*1/2(1670)

BRANDSEN 65 PL 19 420          +ODONNELL, MOORHOUSE           (DURHAM, RHEL)IJP

TRIPP    67 NP B3 10           + LEITH, +       (LRL,SLAC,CERN,HEID,SACLAY)

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET       (SACLAY)IJP
DCNNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK              (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                               (EDIN)
DUKE     68 PR 166 1448        +JONES,KEMP,MURPHY,THRESHER, +      (RHEL,OXF)IJP
      INSIGHTFUL QUALITATIVE ARGUMENTS CONCERNING EXISTENCE AND IJP.
RUSH     68 PR 173 1776        J E RUSH                          (UNIV ALABAMA)

BOTKE    69 PR 180 1417        J C BOTKE                                 (UCSB)
DEANS    69 PR 185 1797        S DEANS, J WOOTEN              (UNIV S FLORIDA)

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET             (SACL)IJP
CARRERAS 70 NP 16B 35          B CARRERAS, A DONNACHIE             (DARE,MCHS)
DAVIES   70 NP B21 359         A DAVIES                                  (GLAS)

BRODY    71 PL 34B 665         +CASHMORE+..+HERNDON+..               (SLAC+LRL)
WAGNER   71 NP B25 411         F WAGNER, C LOVELACE                      (CERN)

ALMEHED  72 NP B40 157         +LOVELACE                         (LUND,RUTG)IJP

DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+           (KYOTO+SAGA+KEK+TOKY)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK                 (GLAS+LBL)IJP

DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN          (DESY,LANC,BONN)IJP
KNIES    74 PRD.9 2680         KNIES,MOORHOUSE,OBERLACK            (LBL,GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                    (CIT)IJP
MOORHOUS 74 PRD 9 1            MOORHOUSE,OBERLACK,ROSENFELD        (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                             (GLAS)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+           (SFLA,ALABAMA)IJP
FELTESSE 75 NP B93 242         +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS  75 SJNP 20 430        +MIROSHNICHENKO,NIKIFOROV,SANIN+         (KIEV)IJP
    ALSO 74 SJNP 19 112        KRIVETS,NIKIFOROV,SANIN,SHALATSKII      (KIEV)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+         (LBL,SLAC)IJP
    ALSO 78 PRD 17 1795        LONGACRE,LASINSKI,ROSENFELD+        (LBL,SLAC)

AYED     76 CEA-N-1921         AYED (THESIS)                            (SACL)IJP
BARBOUR  76 NP B111 358        I. M. BARBOUR,R. L. CRAWFORD             (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP

AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                         (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET            (SACL)IJP

BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS                 (GLAS)
NOVOSELL 78 NP B137 509        D. E. NOVOSELLER                     (CAL TECH)IJP
    ALSO 78 NP B137 445        D. E. NOVOSELLER                     (CAL TECH)IJP

BAKER    79 NP B156 93         +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PRD 20 2839        +FORSYTH,HENDRICK,KELLY             (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN             /KARLSRUHE IJP
SAXON    80 NP B162 522        +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS

BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET          (SACLAY)IJP
DUKE     65 PRL 15 468         +JONES,KEMP,MURPHY,PRENTICE, +     (RHEL,CXF)IJP
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                               (LRL)
DEANS    69 PRL 177 2623       S R DEANS                       (UNIV S FLORIDA)
DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP               (GLAS+EDIN)
AYED     70 PL 31B 598         +BAREYRE+VILLET                         (SACLAY)
BAKER    77 NP B126 365        +BLISSET,BLOODWORTH,BROOME,HART+       (RHEL)IJP
WINNIK   77 NP B128 66         +TOAFF,REVEL,GOLDBERG,BERNY              (HAIF)I
BAKER    78 NP B141 29         +BLISSET,BLOODWORTH,BROMME+          (RL+CAMB)IJP

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Data Card Listings

For notation, see key at front of Listings.

Baryons
N(1688)

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N(1688)   65  N*1/2(1688, JP=5/2+) I=1/2   F'15
          THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                  65  N*1/2(1688) MASS (MEV)

M          (1680.0)                      BRANDSEN  65 RVUE    PHASE SHIFT ANAL  7/66
M    1     (1690.0)                      BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M    1            WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    3     (1687.0)                      DONNACHI  68 RVUE    PHASE-SHIFT ANAL  6/68
M          (1682.0)                      DUKE      68 CNTR    PI-P EL + POL     6/68
M    6     (1682.0)                      AYED      70 IPWA                      1/71
M    6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M    4     (1685.0)                      DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M    7     (1688.)                       ALMEHED   72 IPWA                      2/72
M           1674. TO 1676.               CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
M          (1685.)                       KNASEL    75 DPWA   0 PI- P TO KO LAM 11/75
M    L      1680. OR 1670.               LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    L   THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.    11/75
M          (1679.)                       AYED      76 IPWA                     11/77
M          (1680.)                       BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
M    8     (1660.)                       LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M    8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                          11/77
M     5    (1680.)                       BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
M     5  SUPERSEDES BARBOUR 76.                                                3/79*
M           1680.      15.               CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
M           1684.      3.                HOEHLER   79 IPWA    PI N TO PI N     12/79*
M           . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                  65  N*1/2(1688) WIDTH (MEV)

W    1     (110.0)                       BAREYRE   68 RVUE                     11/67
W    3     (177.0)                       DONNACHI  68 RVUE                      6/68
W    6     (109.0)                       AYED      70 IPWA                      1/71
W    4     (104.0)                       DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
W    7     (140.)                        ALMEHED   72 IPWA                      2/72
W           115. TO  124.                CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
W          (155.)                        KNASEL    75 DPWA   0 PI- P TO KO LAM 11/75
W    L      125. OR  130.                LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W          (126.)                        AYED      76 IPWA                     11/77
W          (120.)                        BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
W    8     (150.)                        LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W     5    (119.)                        BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
W           120.       25.               CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
W           128.       8.                HOEHLER   79 IPWA    PI N TO PI N     12/79*
W           . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                  65  N*1/2(1688) REAL PART OF POLE POSITION (MEV)         11/75

RE         (1688.)                       LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE   8      1656. OR 1653.               LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE         (1666.)                       CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                  65  N*1/2(1688) -2*IMAG PART OF POLE POSITION (MEV)      11/75

IM         (132.)                        LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   8      145. OR 143.                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM         (112.)                        CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                  65  N*1/2(1688) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER        (31.)                         CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                  65  N*1/2(1688) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR        (-15.)                        CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                  65  N*1/2(1688) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1       N*1/2(1688) INTO PI N                         139+ 938
P2       N*1/2(1688) INTO N ETA                        939+ 548
P3       N*1/2(1688) INTO LAMBDA K                    1115+ 497
P4       N*1/2(1688) INTO N*3/2(1232) PI              1232+ 139
P5       N*1/2(1688) INTO N PI PI                      938+ 139+ 139
P6       N*1/2(1688) INTO GAM P, HELICITY=1/2            0+ 938
P7       N*1/2(1688) INTO GAM P, HELICITY=3/2            0+ 938
P8       N*1/2(1688) INTO GAM N, HELICITY=1/2            0+ 939
P9       N*1/2(1688) INTO GAM N, HELICITY=3/2            0+ 939
P10      N*1/2(1688) INTO N EPSILON                    938+1300
P11      N*1/2(1688) INTO N RHO                        938+ 776
P12      N*1/2(1688) INTO N*3/2(1232) PI,P-WAVE       1232+ 139
P13      N*1/2(1688) INTO N*3/2(1232) PI,F-WAVE       1232+ 139
P14      N*1/2(1688) INTO N RHO,S=3/2,P-WAVE           938+ 776
P15      N*1/2(1688) INTO N RHO,S=3/2,F-WAVE           938+ 776
P16      N*1/2(1688) INTO SIGMA K                      493+1189

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                  65  N*1/2(1688) BRANCHING RATIOS

R1       N*1/2(1688) INTO (PI N)/TOTAL                        (P1)
R1   1       (0.64)                      BAREYRE   68 RVUE                     11/67
R1   3       (0.560)                     DONNACHI  68 RVUE                      6/68
R1   6       (0.593)                     AYED      70 IPWA                      1/71
R1   4       (0.54)                      DAVIES    70 RVUE       SOL A AND B    8/69
R1   7       (0.65)                      ALMEHED   72 IPWA                      2/72
R1           (.59)                       AYED      76 IPWA                     11/77
R1            .62        .06             CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
R1            .65        .02             HOEHLER   79 IPWA    PI N TO PI N     12/79*
R1           . . . . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

       MORE INFORMATICN  ON THE INELASTIC DECAY MODES OF THE 1690 MEV
       BUMP, AS SEEN IN PRODUCTION EXPERIMENTS, MAY BE FOUND BELOW
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R2       N*1/2(1688) INTO (N ETA)/TOTAL                          (P2)
R2           (0.015)OR LESS              TRIPP     67 RVUE                      8/67
R2   B       (0.0004)                    BOTKE     69 MPWA    T POLE + RESON.  10/69
R2   B       (0.003)  (0.002)            DEANS     69 MPWA    T POLE + RESON.   5/70
R2   B       (0.0005)OR .001             CARRERAS  70 MPWA    T POLE + RESON.   5/70
R2   B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R3       N*1/2(1688) INTO (N ETA)/(PI N)                         (P2)/(P1)
R3           (0.027)OR LESS              HEUSCH    66 RVUE +  PIO, ETA PHOTO    9/66

R4       N*1/2(1688) INTO (LAMBDA K)/TOTAL                       (P3)
R4           (0.0013)OR LESS             TRIPP     67 RVUE                      8/67
R4   B       (0.001)OR LESS              RUSH      68 MPWA    T POLE + RESON.   5/70
R4   B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING
R4           (0.001)OR LESS  CL=.63      WAGNER    71 IPWA    PI-P TO K LAMB    1/71

R5       N*1/2(1688) INTO (N*3/2(1232) PI)/TOTAL                 (P4)
R5 E 12600   (0.13)   (0.04)  SOLN.A     BRODY     71 HBC     PI-P--2PI N/PWA   6/70
R5 E 12600   (0.39)   (0.10)  SOLN.B     BRODY     71 HBC     PI-P--2PI N/PWA   6/70
R5 E         ASSUMES ELASTIC BRANCHING RATIO 0.62+-0.06

R6       N*1/2(1688) FROM PI N TO K LAMBDA                       SQRT(P1*P3)    4/75
R6            -.009      .009            DEVENISH  74          0 FIXED T DISP REL  4/75
R6           (.01)                       KNASEL    75 DPWA   0 PI- P TO KO LAM 11/75
R6       COUPLING TO LAMBDA K NOT REQUIRED IN THE ANALYSES OF BAKER 77 AND  12/79*
R6       SAXON 80.                                                         12/79*

R7       N*1/2(1688) FROM PI N TO N EPSILON                      SQRT(P1*P10)  11/75
R7   L        (-.28)OR  -.30             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R7   8        (-.31)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R7   8   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R7   N        (-.42)                     NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79*
R7   N   BW FIT TO LONGACRE 75 IPWA.                                            3/79*

R8       N*1/2(1688) FROM PI N TO N*3/2(1232) PI,P-WAVE          SQRT(P1*P12)  11/75
R8   L        (+.26)OR  +.25             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R8   8        (+.27)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R8   8   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R8   N        (+.38)                     NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79*

R9       N*1/2(1688) FROM PI N TO N*3/2(1232) PI,F-WAVE          SQRT(P1*P13)  11/75
R9   L        (0.) OR  (-.08)            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R9   8        (-.07)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R9   N        (-.05)                     NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79*

R10      N*1/2(1688) FROM PI N TO N RHO,S=3/2,P-WAVE             SQRT(P1*P14)  11/75
R10  L        (+.27)OR  +.30             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R10  8        (+.23)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R10  8   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R10  N        (+.34)                     NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79*

R11      N*1/2(1688) FROM PI N TO N RHO,S=3/2,F-WAVE             SQRT(P1*P15)  11/77
R11  8        (+.15)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R11  8   LCNGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R12      N*1/2(1688) FROM PI N TO K SIGMA                        SQRT(P1*P16)  11/75
R12  2       LESS THAN .001              DEANS     75 DPWA    PI N TO K SIGMA  11/75
R12  2   RANGE GIVEN IS FROM 3 OF 4 BEST SOLUTIONS, NOT PRESENT IN SLTN.1.    11/75
R12  2   CEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77            1/78
R12  2   AROUND 1920 MEV.                                                       1/78

R13      N*1/2(1688) FROM PI N TO ETA N                          SQRT(P1*P2)   12/79*
R13          NOT SEEN                    BAKER     79 DPWA   0 PI- P TO ETA N  12/79*

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                  65  N*1/2(1688) PHOTON DECAY AMPL(GEV**-1/2)

       FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
       REVIEW PRECEDING THE BARYON LISTINGS.

A1       N*1/2(1688) INTO GAM P, HELICITY=1/2  (GEV**-1/2)
A1             .015      .023            DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A1           (-.003)                     HEMMI1    73       + FWD PIO PHTOPROD  2/74
A1            -.008      .004            MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A1             .027      .019            DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A1            -.016      .014            KNIES     74 DPWA    PI N PHOTO PROD   2/74
A1            -.008      .011            METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A1            -.014      .003            MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A1            -.013      .002            CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A1           (+.003)                     KRIVETS   75 DPWA    PI-N PHOTO-PROD   1/78
A1           (-.004)                     BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A1            -.009      .002            FELLER    76 DPWA    PI N PHOTO-PROD   2/77
A1            -.007      .002            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79*
A1            +.010      .001            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79*
A1   5        -.005      .015            BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A1           . . . . . . . . .
A1   AVERAGE MEANINGLESS (SCALE FACTOR = 6.3)

A2       N*1/2(1688) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2             .146      .031            DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A2            +.100      .012            MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A2             .163      .011            DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A2             .097      .007            KNIES     74 DPWA    PI N PHOTO PROD   2/74
A2             .129      .016            METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A2             .147      .006            MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A2            +.135      .006            CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A2           (+.107)                     KRIVETS   75 DPWA    PI-N PHOTO-PROD   1/78
A2           (+.132)                     BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A2            +.121      .010            FELLER    76 DPWA    PI N PHOTO-PROD   2/77
A2            +.112      .002            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79*
A2            +.114      .002            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79*
A2   5        +.138      .021            BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A2           . . . . . . . . .
A2   AVERAGE MEANINGLESS (SCALE FACTOR = 3.1)

A3       N*1/2(1688) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3             .035      .049            DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A3            +.017      .014            MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A3             .031      .028            DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A3             .023      .005            KNIES     74 DPWA    PI N PHOTO PROD   2/74
A3             .008      .018            METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A3             .023      .003            MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A3            +.021      .001            CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A3           (+.034)                     BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A3   5        +.037      .010            BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A3           . . . . . . . . .
A3   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
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Baryons

N(1688), N(1700)

Data Card Listings

For notation, see key at front of Listings.

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A4     N*1/2(1688) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4           -.018      .039          DEVENISH  73 DPWA     PI N PHOTO PROD    2/74
A4           -.005      .018          MOORHOUS  73 DPWA     PI N PHOTO-PROD    2/73
A4           -.021      .028          DEVENIS2  74 DPWA     PI N PHOTO-PROD    4/75
A4            .001      .018          KNIES     74 DPWA     PI N PHOTO PROD    2/74
A4            .00       .030          METCALF   74 DPWA     PI N PHOTO-PROD    2/74
A4           -.041      .004          MOORHOUS  74 DPWA     PI N PHOTO-PROD    2/74
A4           -.015      .004          CRAWFORD  75 DPWA     PI N PHOTO-PROD    1/76
A4          (-.028)                   BARBOUR   76 DPWA     PI N PHOTO-PROD    1/76
A4   5       -.038      .018          BARBOUR   78 DPWA     PI-N PHOTO-PROD    3/79*
A4          . . . . . . . . . .
A4   AVERAGE MEANINGLESS (SCALE FACTOR = 2.5)

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REFERENCES FOR N*1/2(1688)

SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.


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BRANDSEN 65 PL 19 420            +ODONNELL, MOORHOUSE           (DURHAM, RHEL)IJP
HEUSCH   66 PRL 17 1019          C A HEUSCH, C Y PRESCOTT, R F DASHEN  (CIT)
TRIPP    67 NP B3 10             + LEITH, +        (LRL,SLAC,CERN,HEID,SACLAY)

BAREYRE  68 PR 165 1731          P BAREYRE, C BRICMAN, G VILLET       (SACLAY)IJP
DCNNACH1 68 PL 26B 161           A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139           DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
    ALSO 68 THESIS               R G KIRSOPP                           (EDIN)
DUKE     68 PR 166 1448          +JONES,KEMP,MURPHY,THRESHER, +    (RHEL,CXF)IJP
RUSH     68 PR 173 1776          J E RUSH                      (UNIV ALABAMA)

BOTKE    69 PR 180 1417          J C BOTKE                             (UCSB)
DEANS    69 PR 185 1797          S DEANS, J WOOTEN           (UNIV S FLORIDA)

AYED     70 KIEV CONF            R AYED,P BAREYRE, G VILLET            (SACL)IJP
CARRERAS 70 NP 16B 35            B CARRERAS, A DONNACHIE          (DARE,MCHS)
CAVIES   70 NP B21 359           A DAVIES                              (GLAS)

BRODY    71 PL 34B 253           +CASHMORE+..+HERNDON+..           (SLAC+LRL)
WAGNER   71 NP B25 411           F WAGNER, C LOVELACE                  (CERN)

ALMEHED  72 NP B40 157           +LOVELACE                       (LUND,RUTG)IJP
DEVENISH 73 PL 47B 53            DEVENISH,RANKIN,LYTH       (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79            HEMMI,INAGAKI+         (KYOTO+SAGA+KEK+TCKY)IJP
MOORHOUS 73 PL 43B 44            MOORHOUSE, OBERLACK              (GLAS+LBL)IJP

DEVENISH 74 NP B81 330           DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2 74 PL 52B 227           DEVENISH,LYTH,RANKIN        (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680           KNIES,MOORHOUSE,OBERLACK          (LBL,GLAS)IJP
METCALF  74 NP B76 253           W J METCALF,R L WALKER                 (CIT)IJP
MOORHOUS 74 PRD 9 1              MOORHOUSE,OBERLACK,ROSENFELD     (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125           R L CRAWFORD                          (GLAS)IJP
DEANS    75 NP B96 90            +MITCHELL,MONTGOMERY,+        (SFLA,ALABAMA)IJP
KNASEL   75 PRD 11 1             +LINDQUIST,NELSON+        (CHIC,WUSL,OSU,ANL)IJP
KRIVETS  75 SJNP 20 430          +MIROSHNICHENKO,NIKIFOROV,SANIN+      (KIEV)IJP
    ALSO 74 SJNP 19 112          KRIVETS,NIKIFOROV,SANIN,SHALATSKII    (KIEV)IJP
LONGACRE 75 PL 55B 415           +ROSENFELD,LASINSKI,SMADJA+       (LBL,SLAC)IJP
    ALSO 78 PRD 17 1795          LONGACRE,LASINSKI,ROSENFELD+      (LBL,SLAC)

AYED     76 CEA-N-1921           AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358          I. M. BARBOUR,R. L. CRAWFORD          (GLAS)IJP
FELLER   76 NP B104 219          +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP

AZNAURYA 77  EFI-264(57)-77      +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
LONGACRE 77 NP B122 493          LONGACRE,DOLBEAU                      (SACL)IJP
    ALSO 76 NP B108 365          DOLBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP

BARBOUR  78 NP B141 253          BARBOUR,CRAWFORD,PARSONS              (GLAS)
NOVOSELL 78 NP B137 509          D. E. NOVOSELLER                  (CAL TECH)IJP
    ALSO 78 NP B137 445          D. E. NOVOSELLER                  (CAL TECH)IJP

BAKER    79 NP B156 93           +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PRD 20 2839          +FORSYTH,HENDRICK,KELLY          (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                 +KAISER,KOCH,PIETARINEN         /KARLSRUHE IJP
SAXON    80 NP B162 522          +BAKER,BELL,BLOODWORTH+          (RHEL+BRIS)IJP
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PAPERS NOT REFERRED TO IN DATA CARDS


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CROUCH   65 DESY CCNF II 21      +   (BROWN,CEA,HARVARD,MIT,PADOVA,WEIZMANN)
DERADO   65 ATHENS CONF 244      +KENNEY,LAMSA, +       (NOTRE DAME,KENTUCKY)
DUKE     65 PRL 15 468           +JONES,KEMP,MURPHY,PRENTICE, +   (RHEL,OXF)IJP
MERLO    66 P ROY SOC 289 489 J P MERLO, G VALLADAS                  (SACLAY)
ROBERTS  67 PREPRINT             R G ROBERTS                         (DURHAM)
BANNER   68 PR 166 1347          +DETOEUF,FAYOUX,HAMEL, +       (SACLAY,CAEN)
    THE ABOVE PAPERS DISCUSS INELASTIC CHANNELS NEAR THE BUMP.
BAREYRE  65 PL 18 342            + BRICMAN, STIRLING, VILLET        (SACLAY)IJP
DEANS    69 PRL 177 2623         S R DEANS                   (UNIV S FLORIDA)
DONNACHI 69 NP 10B 433           A DONNACHIE, R KIRSOPP           (GLAS+EDIN)
AYED     70 PL 31B 598           +BAREYRE+VILLET                     (SACLAY)
BAKER    77 NP B126 365          +BLISSET,BLOODWORTH,BROCME,HART+     (RHEL)IJP
WINNIK   77 NP B128 66           +TOAFF,REVEL,GOLDBERG,BERNY          (HAIF)I
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N(1700) — 18 N*1/2(1700, JP=3/2-) I=1/2 — D''_{13}

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                  18  N*1/2(1700) MASS  (MEV)

M    3     (1730.)                   DONNACH2  68 RVUE     PHAS.SHIFT-CERN1 10/69
M    3     (1680.)                   KIRSOPP   68 RVUE     PHASE SHIFT ANAL 10/69
M    3   WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1   10/69
M    A     (1780.0)                  WAGNER    71 IPWA     PI-P TO K LAMB    1/71
M    A  D13 RESONATES ONLY IN ONE OUT OF 3 POSSIBLE SOL.
M          (1670.)                   DEANS     72 MPWA     GAM P-K LM,SOL D  9/73
M     1    (1790.)                   LANGBEIN  73 IPWA     PI N-K SIG,SOL 1  9/73
M     1  NOT SEEN IN SOLUTION 2 OF LANGBEIN73                                9/73
M     1  DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF     1/78
M     1  WINNIK77 AROUND 1920 MEV.                                           1/78
M     L     1710. OR 1710.           LONGACRE  75 IPWA     PI N TO 2PI N    11/75
M     L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M          (1710.)                   AYED      76 IPWA                      11/77
M    D     (1670.)     (10.)         BAKER     77 IPWA  O PI- P TO K LAM.    1/78
M    E     (1690.)                   BAKER     77 DPWA  O PI- P TO K LAM.    1/78
M    D   THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET     1/78
M    E   ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.           1/78
M    8     (1660.)                   LONGACRE  77 IPWA     PI N TO 2PI N    11/77
M    8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                        11/77
M           1690. TO 1710.           BAKER     78 DPWA  O PI- P TO K LAM     3/79*
M     4    (1719.)                   BARBOUR   78 DPWA     PI-N PHOTO-PROD   3/79*
M    6     (1880.)                   BAKER     79 DPWA  O PI- P TO ETA N    12/79*
M    6   THE HIGH MASS FOUND BY BAKER79 MAY BE INFLUENCED BY THE N(2040).   12/79*
M           1670.        25.         CUTKOSKY  79 IPWA     PI N TO PI N     12/79*
M           1731.        15.         HOEHLER   79 IPWA     PI N TO PI N     12/79*
M    5     (1650.)                   SAXCN     80 DPWA  O PI- P TO K LAM    12/79*
M          . . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 2.1)

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                  18  N*1/2(1700) WIDTH (MEV)

W            (90.)                   DEANS     72 MPWA     GAM P-K LM,SOL D  9/73
W     1     (120.)                   LANGBEIN  73 IPWA     PI N-K SIG,SOL 1  9/73
W     L      100. OR  300.           LONGACRE  75 IPWA     PI N TO 2PI N    11/75
W           (100.)                   AYED      76 IPWA                      11/77
W    D       (90.)      (25.)        BAKER     77 IPWA  O PI- P TO K LAM.    1/78
W    E      (100.)                   BAKER     77 DPWA  O PI- P TO K LAM.    1/78
W    8      (600.)                   LONGACRE  77 IPWA     PI N TO 2PI N    11/77
W              70. TO  100.          BAKER     78 DPWA  O PI- P TO K LAM     3/79*
W     4     (126.)                   BARBOUR   78 DPWA     PI-N PHOTO-PROD   3/79*
W    6       (87.)                   BAKER     79 DPWA  O PI- P TO ETA N    12/79*
W             80.        40.         CUTKOSKY  79 IPWA     PI N TO PI N     12/79*
W            110.        30.         HOEHLER   79 IPWA     PI N TO PI N     12/79*
W    5       (70.)                   SAXON     80 DPWA  O PI- P TO K LAM    12/79*
W          . . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                  18  N*1/2(1700) REAL PART OF POLE POSITION (MEV)      11/75

RE          (1710.)                  LONGACRE  75 IPWA     PI N TO 2PI N    11/75
RE   8       1616. OR 1613.          LONGACRE  77 IPWA     PI N TO 2PI N    11/77
RE          (1660.)                  CUTKOSKY  79 IPWA     PI N TO PI N     12/79*

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                  18  N*1/2(1700) -2*IMAG PART OF POLE POSITION (MEV)   11/75

IM          (607.)                   LONGACRE  75 IPWA     PI N TO 2PI N    11/75
IM   8       577. OR 575.            LONGACRE  77 IPWA     PI N TO 2PI N    11/77
IM          (76.)                    CUTKOSKY  79 IPWA     PI N TO PI N     12/79*

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                  18  N*1/2(1700) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          (4.)                    CUTKOSKY  79 IPWA     PI N TO PI N     12/79*

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                  18  N*1/2(1700) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR          (-.3)                   CUTKOSKY  79 IPWA     PI N TO PI N     12/79*

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                  18  N*1/2(1700) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      N*1/2(1700) INTO PI N                             139+ 938
P2      N*1/2(1700) INTO LAMBDA K                        1115+ 497
P3      N*1/2(1700) INTO GAM P,HELICITY=3/2                 0+ 938
P4      N*1/2(1700) INTO GAM P,HELICITY=1/2                 0+ 938
P5      N*1/2(1700) INTO GAM N,HELICITY=3/2                 0+ 939
P6      N*1/2(1700) INTO GAM N,HELICITY=1/2                 0+ 939
P7      N*1/2(1700) INTO K SIGMA                          493+1189
P8      N*1/2(1700) INTO N EPSILON                        938+1300
P9      N*1/2(1700) INTO N*3/2(1232) PI,S-WAVE           1232+ 139
P10     N*1/2(1700) INTO N*3/2(1232) PI,D-WAVE           1232+ 139
P11     N*1/2(1700) INTO N RHO,S=3/2,S-WAVE               938+ 776
P12     N*1/2(1700) INTO ETA N                            939+ 548

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                  18  N*1/2(1700) BRANCHING RATIOS

R1      N*1/2(1700) FROM GAMMA PROTON TO K LAMBDA        SQRT((P3+P4)*P2)    9/73
R1            (.0077)                DEANS     72 MPWA     GAM P-K LM,SOL D  9/73

R2      N*1/2(1700) FROM PI N TO K SIGMA                 SQRT(P1*P7)         9/73
R2    1       (.10)                  LANGBEIN  73 IPWA     PI N-K SIG,SOL 1  9/73
R2   2      LESS THAN .017           DEANS     75 DPWA     PI N TO K SIGMA  11/75
R2   2   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                           11/75

R3      N*1/2(1700) INTO PI N/TOTAL                      (P1)
R3            (.09)                  AYED      76 IPWA                      11/77
R3             .10       .02         CUTKOSKY  79 IPWA     PI N TO PI N     12/79*
R3             .08       .03         HOEHLER   79 IPWA     PI N TO PI N     12/79*
R3         . . . . . . . . . .
R3   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R4      N*1/2(1700) FROM PI N TO K LAMBDA                SQRT(P1*P2)         4/75
R4           +.026      .019         DEVENISH  74          O FIXED T DISP REL  4/75
R4   D       (-.03)    (.004)        BAKER     77 IPWA  O PI- P TO K LAM.    1/78
R4   E       (-.03)                  BAKER     77 DPWA  O PI- P TO K LAM.    1/78
R4    9      (-.04)                  BAKER     78 DPWA  O PI- P TO K LAM     3/79*
R4    9  THE (UNDETERMINED) OVERALL PHASE OF ALL COUPLINGS FROM BAKER78      3/79*
R4    9  HAS BEEN CHANGED TO AGREE WITH PREVIOUS CONVENTIONS.                3/79*
R4   5       (-.012)                 SAXON     80 DPWA  O PI- P TO K LAM    12/79*
R4   5   SUPERSEDES BAKER 78.                                               12/79*

R5      N*1/2(1700) FROM PI N TO N EPSILON               SQRT(P1*P8)        11/75
R5    L      (-.2) OR  -.2           LONGACRE  75 IPWA     PI N TO 2PI N    11/75
R5   8        (.00)                  LONGACRE  77 IPWA     PI N TO 2PI N    11/77

R6      N*1/2(1700) FROM PI N TO N*3/2(1232) PI,S-WAVE   SQRT(P1*P9)        11/75
R6    L      (+.15)OR  +.16          LONGACRE  75 IPWA     PI N TO 2PI N    11/75
R6   8        (.00)                  LONGACRE  77 IPWA     PI N TO 2PI N    11/77

R7      N*1/2(1700) FROM PI N TO N*3/2(1232) PI,D-WAVE   SQRT(P1*P10)       11/75
R7    L      (-.10)OR  -.14          LONGACRE  75 IPWA     PI N TO 2PI N    11/75
R7   8       (+.12)                  LONGACRE  77 IPWA     PI N TO 2PI N    11/77
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Data Card Listings

For notation, see key at front of Listings.

Baryons
N(1700)

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R8      N*1/2(1700) FROM PI N TO N RHO,S=3/2,S-WAVE         SQRT(P1*P11)          11/75
R8  L        (0.) OR  (-.07)             LONGACRE  75 IPWA    PI N TO 2PI N       11/75
R8  8        (+.07)                      LONGACRE  77 IPWA    PI N TO 2PI N       11/77

R9      N*1/2(1700) FROM PI N TO ETA N                      SQRT(P1*P12)          12/79*
R9           (.065)                      BAKER     79 DPWA  0 PI- P TO ETA N      12/79*

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                    18  N*1/2(1700) PHOTON DECAY AMPL(GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*1/2(1700) INTO GAM P, HELICITY=1/2  (GEV**-1/2)
A1             -.103     .130            DEVENISH  73 DPWA    PI N PHOTO PROD      2/74
A1             -.048     .050            DEVENIS2  74 DPWA    PI N PHOTO-PROD      4/75
A1             -.015     .040            KNIES     74 DPWA    PI N PHOTO PROD      2/74
A1              .0       .034            METCALF   74 DPWA    PI N PHOTO-PROD      2/74
A1             (.023)                    MOORHOUS  74 DPWA    PI N PHOTO PROD      2/74
A1             -.012     .010            CRAWFORD  75 DPWA    PI N PHOTO-PROD      1/76
A1            (-.005)                    BARBOUR   76 DPWA    PI N PHOTO-PROD      1/76
A1             -.014     .025            FELLER    76 DPWA    PI N PHOTO-PROD      2/77
A1             +.078     .008            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1    12/79*
A1             +.038     .005            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2    12/79*
A1   4         -.033     .021            BARBOUR   78 DPWA    PI-N PHOTO-PROD      3/79*
A1   4  SUPERSEDES BARBOUR 76.                                                     3/79*
A1          . . . . . . . . . . .
A1   AVERAGE MEANINGLESS (SCALE FACTOR = 4.1)

A2      N*1/2(1700) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2              .055     .065            DEVENISH  73 DPWA    PI N PHOTO PROD      2/74
A2             -.006     .014            DEVENIS2  74 DPWA    PI N PHOTO-PROD      4/75
A2              .030     .040            KNIES     74 DPWA    PI N PHOTO PROD      2/74
A2              .0       .029            METCALF   74 DPWA    PI N PHOTO-PROD      2/74
A2             (.035)                    MOORHOUS  74 DPWA    PI N PHOTO PROD      2/74
A2             -.012     .010            CRAWFORD  75 DPWA    PI N PHOTO-PROD      1/76
A2            (-.009)                    BARBOUR   76 DPWA    PI N PHOTO-PROD      1/76
A2              .0       .014            FELLER    76 DPWA    PI N PHOTO-PROD      2/77
A2             -.066     .007            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1    12/79*
A2             -.048     .007            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2    12/79*
A2   4         -.014     .025            BARBOUR   78 DPWA    PI-N PHOTO-PROD      3/79*
A2          . . . . . . . . . . .
A2   AVERAGE MEANINGLESS (SCALE FACTOR = 2.6)

A3      N*1/2(1700) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3              .013     .222            DEVENISH  73 DPWA    PI N PHOTO PROD      2/74
A3             -.021     .098            DEVENIS2  74 DPWA    PI N PHOTO-PROD      4/75
A3             -.036     .040            KNIES     74 DPWA    PI N PHOTO PROD      2/74
A3              .0       .034            METCALF   74 DPWA    PI N PHOTO-PROD      2/74
A3            (-.015)                    MOORHOUS  74 DPWA    PI N PHOTO PROD      2/74
A3             +.081     .015            CRAWFORD  75 DPWA    PI N PHOTO-PROD      1/76
A3            (+.017)                    BARBOUR   76 DPWA    PI N PHOTO-PROD      1/76
A3   4         +.050     .042            BARBOUR   78 DPWA    PI-N PHOTO-PROD      3/79*
A3          . . . . . . . . . . .
A3   AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

A4      N*1/2(1700) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4             -.088     .087            DEVENISH  73 DPWA    PI N PHOTO PROD      2/74
A4             -.026     .067            DEVENIS2  74 DPWA    PI N PHOTO-PROD      4/75
A4              .024     .024            KNIES     74 DPWA    PI N PHOTO PROD      2/74
A4              .0       .044            METCALF   74 DPWA    PI N PHOTO-PROD      2/74
A4             (.028)                    MOORHOUS  74 DPWA    PI N PHOTO PROD      2/74
A4             +.107     .025            CRAWFORD  75 DPWA    PI N PHOTO-PROD      1/76
A4            (+.022)                    BARBOUR   76 DPWA    PI N PHOTO-PROD      1/76
A4   4         +.035     .030            BARBOUR   78 DPWA    PI-N PHOTO-PROD      3/79*
A4          . . . . . . . . . . .
A4   AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

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REFERENCES FOR N*1/2(1700)


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DONNACH2 68 VIENNA 139          DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
KIRSOPP  68 THESIS              R G KIRSOPP                           (EDIN)
WAGNER   71 NP B25 411          F WAGNER, C LOVELACE                  (CERN)
DEANS    72 PRD 6 1906          DEANS,JACOBS, LYONS,MONTGOMERY (SOUTH FLA.)IJP
DEVENISH 73 PL 47B 53           DEVENISH,RANKIN,LYTH        (LOUC+BONN+LANC)IJP
LANGBEIN 73 NP B53 251          LANGBEIN,WAGNER                     (MUNICH)IJP

DEVENISH 74 NP B81 330          DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LCUC)
DEVENIS2 74 PL 52B 227          DEVENISH,LYTH,RANKIN        (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680          KNIES,MOORHOUSE,OBERLACK          (LBL,GLAS)IJP
METCALF  74 NP B76 253          W J METCALF,R L WALKER                 (CIT)IJP
MOORHOUS 74 PRD 9 1             MOORHOUSE,OBERLACK,ROSENFELD      (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125          R L CRAWFORD                          (GLAS)IJP
DEANS    75 NP B96 90           +MITCHELL,MONTGOMERY,+         (SFLA,ALABAMA)IJP
LONGACRE 75 PL 55B 415          +ROSENFELD,LASINSKI, SMADJA+      (LBL,SLAC)IJP
    ALSO 78 PRD 17 1795         LONGACRE,LASINSKI,ROSENFELD+      (LBL,SLAC)

AYED     76 CEA-N-1921          AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358         I. M. BARBOUR,R. L. CRAWFORD          (GLAS)IJP
FELLER   76 NP B104 219         +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP

AZNAURYA 77  EFI-264(57)-77     +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
BAKER    77 NP B126 365         +BLISSET,BLOODWORTH,BROOME,HART+      (RHEL)IJP
LONGACRE 77 NP B122 493         LONGACRE,DOLBEAU                      (SACL)IJP
    ALSO 76 NP B108 365         DOLBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP

BAKER    78 NP B141 29          +BLISSET,BLOODWORTH,BROOME+        (RL+CAMB)IJP
BARBOUR  78 NP B141 253         BARBOUR,CRAWFORD,PARSONS              (GLAS)

BAKER    79 NP B156 93          +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PRD 20 2839         +FORSYTH,HENDRICK,KELLY           (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN          /KARLSRUHE IJP
SAXON    80 NP B162 522         +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
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PAPERS NOT REFERRED TO IN DATA CARDS

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HERNDON  72 LBL 1065            +...ROSENFELD...+CASHMORE+...     (LBL,SLAC)
WINNIK   77 NP B128 66          +TOAFF,REVEL,GOLDBERG,BERNY           (HAIF)I
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1700 MEV REGION – PRODUCTION EXPERIMENTS

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                  20  N*1/2(1700, JP=     ) I=1/2   PRODUCTION EXPERIMENTS

                  SEE THE MINI-REVIEW PRECEDING THE N AND DELTA LISTINGS
                  FOR DISCUSSION OF PRODUCTION EXPERIMENTS.

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                  20  N*1/2(1700) MASS (MEV) (PROD. EXP.)

M         (1695.0)    (9.0)              A-BORELLI 67 HBC  +  PBAR P 5.7 BEV/C  8/67
M         (1734.0)   (21.0)              ALMEIDA   68 HBC  +  PP 10 BEV/C       9/69
M         (1730.0)   (18.0)              GALLOWAY  68 HBC     PI-P 6 GEV/C      8/69
M   1     (1712.0)    (6.0)              BARNES    69 HBC     K-P TO K-P 2PI    7/70
M   1      IJP CONSISTENT WITH S11(1650) OR P11(1710) IN FORMATION
M   A     (1667.0)    (5.0)              BENVENUTI 69 DBC   0 PI-D 2.26 GEV     5/70
M   A         J CONSISTENT WITH 5/2 OR 7/2
M   B  190(1693.)     (15.)              RHODE     69 HBC     PP 22 GEV/C      10/69
M   B  JP IS PROBABLY 5/2+
M         (1691.)     (4.)               ANDERSON  70 MMS  -  PI- P TO PI- MMS  2/71
M      177(1710.)    (10.)               CIRBA     70 HBC  +  PI+ P TO P+3PI    2/71
M       40(1763.)    (25.)               COOPER    70 HBC  +  LAMB. K PROD.     2/71
M      505(1730.0)   (15.0)              CRENNELL  70 HBC  +  PI-P,PI+P 6 GEV   1/71
M       60(1710.)                        KUZNETSOV 70 HLBC -  LAMB. K PROD.     2/71
M   A     (1719.0)    (6.0)              WILLMANN  70 HBC  +  PI+P 13. GEV      5/70
M   A         J CONSISTENT WITH 5/2 OR 7/2
M         (1694.0)    (8.0)              AMALDI    71 SAS     P P AT 24 GEV    10/71
M         (1730.)    (20.)               BALLAM    71 HBC  +- PI+-P AT 16GEV    2/72
M         (1700.)                        BEKETOV   71 HBC  +  PI- P 4.45GEV/C   3/72
M         (1711.)    (10.)               BOESEBEC  71 RVUE    PP,PI-P,K-P PROD  3/72
M         (1672.0)    (4.0)              ELLIS     71 CNTR    MMS PP 3.7 GEV/C 10/71
M       80(1650.0)   (10.0)    80/120    MA        71 HBC  +  P P TO P N PI    10/71
M         (1700.0)   (10.0)              MORSE     71 HBC  +  PI-P   25 GEV/C   3/72
M          1670. TO 1730.                MORSE     71 HBC  +0 PI-P  7   GEV/C   3/72
M         (1720.)    (20.)               RUSHBROOKE71 HBC  +  PP TO P2PI 16GEV  2/72
M         (1690.3)    (4.5)              EDELSTEIN 72 MMS  +  PP 6 TO 30 GEV    1/73
M         (1668.0)   (19.0)     24/45    KARSHON   72 DBC  +  PD--PD2PI 7 GEV  12/72
M  C      (1715.0)    (5.0)              LAMSA     72 HBC  +  PI+-P 8TO18 GEV   1/73
M  C   ANALYSIS GIVES JP = 5/2+
M    2    (1660.)  (15.                  OH        72 DBC   0 PI-N TO PI-PI-P   2/73
M    2   DETERMINE J=5/2,F15 PROBABLE                                           2/73
M         (1720.)    (15.)               RONAT     72  HBC    PI+P TO 3PI P     2/73
M   3     (1820.)                        DAVIDSON  74 HBC   + PI-P TO PI- OM P 10/74
M   3   OMEGA PROTON ENHANCEMENT,MOMENTS ANALYSIS CONSISTENT WITH 2J=1 OR 3 10/74
M         (1732.)     (7.)               LICHTMAN  74 HBC  +  PI+P TO 3PI P     4/75
M         (1694.)    (10.)               LICHTMAN  74 HBC  +  PI-P TO 3PI P     4/75
M   5     (1810.)    (15.)               ATHERTO2  75 HBC     PBAR P 5.7 GEV    2/77
M   5   OMEGA PROTON ENHANCEMENT, MOMENTS ANALYSIS CONSISTENT WITH S STATE.  2/77
M   4     (1700.)                        BLOBEL    75 HBC  +  PP TO P(PI+PI-P)  1/76
M   4   PWA INDICATES PI+PI-P ENHANCEMENT IS PRIMARILY A                        1/76
M   4   P-WAVE P EPSILON SYSTEM WITH I,JP=1/2,3/2-.                             1/76
M          1660. TO 1670.                BRAUN1    75 HBC     PBAR P 5.7 GEV   11/75
M         (1691.)    (11.)               CAVALLI   75 SPEC +  PP TO 2N*,W=23GV  1/76
M         (1691.)     (8.)               CAVALLI   75 SPEC +  PP TO 2N*,W=31GV  1/76
M         (1715.)    (10.)               CAVALLI   75 SPEC +  PP TO 2N*,W=53GV  1/76
M         (1686.)    (12.)               MUSGRAVE  75 HBC     K+ P TO K PI N   11/75
M         (1650.)                        STRACHMA  75  BC     NBAR (N PI)       1/76
M         (1678.)     (4.)               WEBB      75 ISR  +  P P TO P N*       1/76
M         (1691.)     (4.)               ATHERTON  76 HBC     PBAR P 5.7 GEV    2/77
M         (1680.)    (25.)               APPLE     77 SPEC +  P P TO P (P PIO)  1/78
M         (1660.)    (20.)               APPLE     77 SPEC +  P P TO P (N PI+)  1/78
M         (1690.)    (10.)               HEINEN    77 HBC  +  K-P TO K- N*+     1/78
M         (1670.)    (10.)               HEINEN    77 HBC   0 K-P TO KOBAR N*0  1/78
M  G      (1677.)     (2.)               ROUGE     77 OMEG  0 PI-P 9,12 GEV/C   1/78
M  G   BACKWARD PRODUCTION. PI- P --> (P PI-) PIO. CONSISTENT WITH JP=5/2+
M         (1710.)    (20.)               EKELOF    78 SPEC +  P HE--P PI PI HE  1/78
M  H 2.5K(1680.)      (3.)               FERRER    78 OMEG  0 PI-P 9,12 GEV/C   3/79*
M  H   BACKWARD PRODUCTION. PI- P --> (P PI-) PI+ PI-
M  I   185(1664.)    (15.)               FERRER    78 OMEG +  PI-P 9,12 GEV/C   3/79*
M  I   BACKWARD PRODUCTION. PI- P --> (P PI+ PI-) PI-. JP=5/2- FAVORED.
M       50(1714.)    (25.)               GODDARD   78 HBC  +  PI+P TO LAM K PI  3/79*
M  F      (1670.)                        OTTER     78 HBC  +  K-P TO K- N*+     1/78
M  F   FROM PARTIAL WAVE ANALYSIS OF P PI+ PI- SYSTEM.  SHAPE OF                1/78
M  F   5/2-D(DELTA PI) WAVE IS COMPATIBLE WITH A BREIT-WIGNER.                  1/78
M      410(1690.)     (6.)               APELDOORN 79 HBC  +- PBAR P 7.2 GEV/C 12/79*

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                  20  N*1/2(1700) WIDTH (MEV) (PROD. EXP.)

W           (70.0)   (20.0)              A-BORELLI 67 HBC                        9/69
W          (140.0)   (57.0)              ALMEIDA   68 HBC  +                     9/69
W           (55.0)   (15.0)              GALLOWAY  68 HBC                        8/69
W   1       (70.0)   (15.0)              BARNES    69 HBC     K-P TO K-P 2PI     7/70
W   A      (105.0)   (16.0)              BENVENUTI 69 DBC   0                    5/70
W   B  190 (235.)    (50.)               RHODE     69 HBC     PP 22 GEV/C       10/69
W          (130.)    (10.)               ANDERSON  70 MMS  -  PI- P TO PI- MMS   2/71
W      177  (66.)    (26.)               CIRBA     70 HBC  +  PI+ P AT 5 GEV/C   2/71
W          (102.)    (40.)               COOPER    70 HBC  +  PI+P, 5.5 GEV/C    2/71
W      505 (130.0)   (30.0)              CRENNELL  70 HBC  +                     1/71
W       60 (220.)                        KUZNETSOV 70 HLBC -  PI-P, 4 GEV/C      2/71
W   A       (63.0)   (12.0)              WILLMANN  70 HBC  +                     5/70
W          (152.0)   (15.0)              AMALDI    71 SAS     P P AT 24 GEV     10/71
W          (120.)    (50.)               BALLAM    71 HBC  +- PI+-P AT 16GEV     2/72
W           (57.)    (15.)               BOESEBEC  71 RVUE    PP,PI-P,K-P PROD   3/72
W          (102.0)    (9.0)              ELLIS     71 CNTR    MMS PP 3.7 GEV/C  10/71
W       80  (94.0)   (20.0)    80/120    MA        71 HBC  +  P P TO P N PI     10/71
W           (70.)    (20.)               MORSE     71 HBC  +  PI-P   25 GEV/C    3/72
W            70. TO  120.                MORSE     71 HBC  +0 PI-P  7   GEV/C    3/72
W          (120.)    (40.)               RUSHBROOKE71 HBC  +  PP TO P2PI 16GEV   2/72
W          (133.0)   (26.0)              EDELSTEIN 72 MMS  +  PP 6 TO 30 GEV     1/73
W          (168.0)   (64.0)              KARSHON   72 DBC  +  PD--PD2PI 7 GEV   12/72
W           (80.0)  APPROX.              LAMSA     72 HBC     PI P  18.5 GEV/C  12/72
W    2    (128.)   (40.                  OH        72 DBC   0 PI-N TO PI-PI-P    2/73
W           (60.)    (40.)               RONAT     72  HBC    PI+P TO 3PI P      2/73
W          (157.)    (12.)               ABE       74      +  P+P->P+X,JCBN PK   4/75
W   3      (120.)                        DAVIDSON  74 HBC   + PI-P TO PI- OM P  10/74
W           (34.)    (14.)               LICHTMAN  74 HBC  +  PI+P TO 3PI P      4/75
W           (48.)    (20.)               LICHTMAN  74 HBC  +  PI-P TO 3PI P      4/75
W   5       (87.)    (20.)               ATHERTO2  75 HBC     PBAR P 5.7 GEV     2/77
W          (140.)                        BRAUN1    75 HBC     PBAR P 5.7 GEV    11/75
W          (188.)   (112.)               CAVALLI   75 SPEC +  PP TO 2N*,W=23GV   1/76
W          (133.)    (38.)               CAVALLI   75 SPEC +  PP TO 2N*,W=31GV   1/76
W          (100.)    (10.)               CAVALLI   75 SPEC +  PP TO 2N*,W=53GV   1/76
W          (135.)    (20.)               MUSGRAVE  75 HBC     K+ P TO K PI N    11/75
W          (148.)    (16.)               WEBB      75 ISR  +  P P TO P N*        1/76
W          (194.)    (10.)               ATHERTON  76 HBC     PBAR P 5.7 GEV     2/77
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Baryons
N(1700), N(1710)

Data Card Listings
For notation, see key at front of Listings.

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W          (150.)   (100.)           APPLE      77 SPEC +  P P TO P (P PIO)  1/78
W          (150.)    (70.)           APPLE      77 SPEC +  P P TO P (N PI+)  1/78
W          (120.)    (20.)           HEINEN     77 HBC  +  K-P TO K- N*+     1/78
W           (90.)    (30.)           HEINEN     77 HBC   0 K-P TO KOBAR N*0  1/78
W   G      (130.)     (6.)           ROUGE      77 OMEG  0 PI-P 9,12 GEV/C   1/78
W          (200.)                    EKELOF     78 SPEC +  P HE--P PI PI HE  1/78
W  H 2.5K  (121.)     (7.)           FERRER     78 OMEG  0 PI-P 9,12 GEV/C   3/79*
W  I  185  (121.)    (23.)           FERRER     78 OMEG +  PI-P 9,12 GEV/C   3/79*
W      50  (208.)    (50.)           GODDARD    78 HBC  +  PI+P TO LAM K PI  3/79*
W  F       (150.)                    OTTER      78 HBC  +  K-P TO K- N*+     1/78
W     410  (120.)    (10.)           APELDOORN 79 HBC  +- PBAR P 7.2 GEV/C 12/79*
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED
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               20  N*1/2(1700) PARTIAL DECAY MODES (PROD. EXP.)

                                                         DECAY MASSES
P1      N*1/2(1700) INTO PI N                          139+ 938
P2      N*1/2(1700) INTO N PI PI                       938+ 139+ 139
P3      N*1/2(1700) INTO N*3/2(1232) PI               1232+ 139
P4      N*1/2(1700)+ INTO NEUTRON PI+                  939+ 139
P5      N*1/2(1700)+ INTO PROTON PI+ PI-               938+ 139+ 139
P6      N*1/2(1700)+ INTO N*3/2(1232)++ PI-           1232+ 139
P7      N*1/2(1700) INTO N ETA                         939+ 548
P8      N*1/2(1700) INTO LAMBDA K                     1115+ 497
P9      N*1/2(1700) INTO SIGMA K                      1189+ 493
P10     N*1/2(1700) INTO OMEGA PROTON                  782+ 938
P11     N*1/2(1700) INTO RHOO PROTON                   776+ 938
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               20  N*1/2(1700) BRANCHING RATIOS (PROD. EXP.)

R1      N*1/2(1700) INTO (PI N)/(PI N*3/2(1232))          (P1)/(P3)
R1            (0.77) OR LESS          LEE       67 HBC     PI-P 3.6 GEV/C   11/67
R1   A        (9.0)  OR MORE          BENVENUTI 69 DBC   0                   5/70

R2      N*1/2(1700) INTO (N ETA)/(N PI + N PI PI)         (P7)/(P1+P2)
R2            (0.025)OR LESS          KRAEMER   64 DBC  +  PI+D 1.2
R2            (0.042)OR LESS  CL=.95  A-BORELLI 67 HBC  +  PBAR P 5.7 BEV/C  9/69

R3      N*1/2(1700) INTO (LAMBDA K)/(P PI+ PI-)           (P8)/(P5)
R3            (0.034)OR LESS          ALEXANDER 67 HBC  +  PP 5.5 BEV/C     11/67
R3            (0.07) OR LESS  CL=.95  CIRBA     70 HBC     PI+P AT 5 GEV/C   2/71
R3            (0.01)                  BAKSAY    76 ISR  +  PP--N*P           1/78

R4      N*1/2(1700) INTO (LAMBDA K)/(N PI + N PI PI)      (P8)/(P1+P2)
R4            (0.013)OR LESS  CL=.95  A-BORELLI 67 HBC  +                    8/67
R4              SEEN                  CHINOWSKY 68 HBC     PP TO K+ Y N      6/68
R4   1       LIMITS 0.025 TO 0.11     BARNES    69 HBC     K-P TO K-P 2PI    7/70
R4      25     0.025     0.005        CRENNELL  70 HBC  +                    1/71
R4   A      LESS THAN    0.025        WILLMANN  70 HBC     PI+P TO 3PI P     6/70
R4      25  SEEN. CONS. WITH J=1/2    MORSE     71 HBC   0 PI-P  7   GEV/C   3/72

R5      N*1/2(1700) INTO (N PI)/(N PI PI)                 (P1)/(P2)
R5            (1.26) OR LESS  CL=.95  A-BORELLI 67 HBC  +                    8/67
R5             0.025     0.13         CRENNELL  70 HBC  +                    1/71

R6      N*1/2(1700) INTO (N*3/2(1232) PI)/(N PI PI)       (P3)/(P2)
R6             NO EVIDENCE            A-BORELLI 67 HBC  +                    8/67
          SEE MERLO 66 FOR A REVIEW.

R7      N*1/2(1700) INTO (NEUTRON PI+)/(P PI+ PI-)        (P4)/(P5)
R7             0.67      0.40         ALEXANDER 67 HBC  +  PP 5.5 BEV/C     11/67
R7             0.47      0.25         A-BORELLI 67 HBC     PBAR P 5.5 GEV/C  7/70
R7           . . . . . . . . . .
R7   AVG       0.53      0.21     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R7   STUDENT   0.53      0.23     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R8      N*1/2(1700) INTO (N*3/2(1232)++ PI-)/(P PI+ PI-) (P6)/(P5)
R8             0.74      0.14         ALEXANDER 67 HBC  +  PP 5.5 BEV/C     11/67
R8             1.0       0.3          ALMEIDA   68 HBC  +  PP 10 BEV/C       9/66
R8            (0.83)                  KAYAS     68 HBC     PP 8.1 BEV/C     11/68
R8   1      LESS THAN    0.15         BARNES    69 HBC     K-P TO K-P 2PI    7/70
R8            (0.50) OR LESS  CL=.95  CIRBA     70 HBC     PI+P AT 5 GEV/C   2/71
R8             NO EVIDENCE            CRENNELL  70 HBC  +                    1/71
R8   A        (2.3)     (1.6)         WILLMANN  70 HBC     PI+P TO 3PI P     6/70
R8            (1.0)  OR MORE  CL=.95  BEKETOV   71 HBC  +  DEL(1232)++ PI-   3/72
R8             0.75      0.75         BOESEBEC  71 RVUE    PP,PI-P,K-P PROD  3/72
R8             0.35      0.20         RUSHBROOKE71 HBC  +  PP TO P2PI 16GEV  2/72
R8 C           0.65      0.15         LAMSA     72 HBC     PI P  18.5 GEV/C 12/72
R8            (0.40)                  BLOBEL    75 HBC  +  PP TO P(PI+PI-P)  1/78
R8             0.3       0.1          HEINEN    77 HBC  +  K-P TO K- N*+     1/78
R8             0.42      0.08         EKELOF    78 SPEC +  P HE--P PI PI HE  1/78
R8           . . . . . . . . . .
R8   AVG       0.471     0.078    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
R8   STUDENT   0.465     0.064    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R9      N*1/2(1700) INTO (SIG K)/(LAMB K)                 (P9)/(P8)
R9          LESS THAN     .20         COOPER    70 HBC  +  PI+P, 5.5 GEV/C   2/71

R10     N*1/2(1700) INTO (PI N)+/(OMEGA PROTON)           (P1)/(P10)
R10      LESS THAN .36 (90 PCT CL)    DAVIDSON  74 HBC   + PI-P TO PI- OM P 10/74

R11     N*1/2(1700) INTO (RHOO PROTON)/(OMEGA PROTON)     (P11)/(P10)
R11      LESS THAN .12 (90 PCT CL)    DAVIDSON  74 HBC   + PI-P TO PI- OM P 10/74

        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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REFERENCES FOR N*1/2(1700) (PROD. EXP.)


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KRAEMER   64 PR 136 B496         +MADANSKY,+  (J HOPKINS,NWESTERN,WOODSTOCK) I

ALEXANDE 67 PR 154 1284          ALEXANDER,BENARY,CZAPEK,+  (WEIZMANN(CERN))
A-BORELL 67 NC 47 232            ALLES-BORELLI,FRENCH,FRISK,MICHEJDA  (CERN)
LEE      67 PR 159 1156          +MOEBS,ROE,SINCLAIR,VANDER VELDE     (MICH)

ALMEIDA  68 PR 174 1638          +RUSHBROOKE, +               (CAVE,DESY(CERN))
CHINOWSK 68 PR 165 1466          CHINOWSKY,KINSEY,KLEIN, +          (LRL,SLAC)
GALLOWAY 68 PL 27B 250           GALLOWAY,ALYEA,CRITTENDEN,PRICKETT,+  (IND)
KAYAS    68 NP B5 169            +GUYADER,SENE,YIOU,ALITTI,+  (ORSAY,SACLAY)

BARNES   69 PRL 23 1516          +BASSANO+CHUNG+EISNER+FLAMINTO+KINSON (BNL)IJ
BENVENUT 69 PR 187 1852          BENVENUTI, MARQUIT, OPPENHEIMER (MINN,COLO)
RHODE    69 PR 187 1844          RHODE, LEACOCK, KERNAN, JESPERSEN,+   (ISU)

ANDERSON 70 PRL 25,699           +BLESER,BLIEDEN,COLLINS++          (BNL,CARN)
CIRBA    70 NP B23,533           +VANDERHAGEN+    (EPOL,DURH,NIJM, TORI,BONN)
COOPER   70 NP B23,605           +MANNER,MUSGRAVE,POLLARD,VOYVODIC     (ANL)
CRENNELL 70 PRL 25 187           +LAI, LOUIE, SCARR, SIMS              (BNL)
KUZNETSOV70 SJNP 10,332          +MELNIKOV,RYLTSEVA,CHADRAA,BALINTP   (JINR)
WILLMANN 70 PRL 24 1260          +LAMSA,GAIDOS,EZELL                  (PURD)IJ

AMALDI   71 PL  34B 435          +BIANCASTELLI,BOSIO,+  (I SANITA ROMA+CERN)
BALLAM   71 PR D4 1946           +CHADWICK,GUIRAGOSSIAN,JOHNSON,++     (SLAC) I
BEKETOV  71 SJNP 13 605          ,ZOMBKOVSKII,KONOVALOV,KRUCHININ,++  (ITEP)IJ
BOESEBEC 71 NP B33 445           BOESEBECK,GRAESSLER,KRAUS,+++       (ABBCHLV) I
ELLIS    71 PRL 27 442           +MAGLICH,NOREM,SANNES,SILVERMAN        (RUTG)
MA       71 PRL  26  333         +COLTON                             (MSU+LBL)I
MORSE    71 PR D4 133            +OH,WALKER,CARROLL,LYNCH +        (WISC+TNTO)I
RUSHBROO 71 PR D4 3273           RUSHBROOKE,WILLIAMS+BAREFORD++  (CAVE,LCIC) IJ

EDELSTEI 72 PR D5 1073           EDELSTEIN,CARRIGAN,HIEN,MCMAHON,+(CARN+BNL)
JOHNSTAD 72 NP B42 588           +MOLLERUD+...+JACOBSEN(BOHR,HELS,OSLO,STOH) IJP
KARSHON  72 NP B37 371           +YEKUTIELI,YAFFE,SHAPIRA,RONAT,+       (REHO) I
LAMSA    72 NP B37 364           +WILLMANN+..+GO,BISWAS+...       (PURD,NDAM) IJP
OH       72 PL 42B 497           +FUNG,KERNAN,POE,SCHALK,SHEN           (UCR)IJP
RONAT    72 NP B38 20            +EISENBERG,LYONS,SHAPIRA,TOAFF+        (REHO)

ABE      74 PL 53B 114           +ALSPECTOR,BOMBEROWITZ+       (RUTG,UPNJ,FSU)
DAVIDSON 74 PRL 32 855           DAVIDSON,DZIERBA,FIRESTONE,+  (CIT+BNL+LBL)I
LICHTMAN 74 NP B81 31            LICHTMAN,BISWAS,CASON,KENNEY,MCGAHAN+(NDAM)I

ATHERTO2 75 NC 30A 505           ATHERTON,BAR-NIR,FRENCH,SKURA+  (CERN+PRAG)
BLOBEL   75 NP B97 201           +ESKREYS,FESEFELDT,FRANZ+  (BONN+HAMB+MPIM)IJP
BRAUN1   75 NP B95 481           +GERBER,MAURER,MICHALON,SCHIBY+ (STRB,LPNP)I
CAVALLI  75 LNC 14 353           CAVALLI-SFORZA,CONTA+             (PAVIA+PRIN)
    ALSO 75 LNC 14 345+359       CAVALLI-SFORZA,CONTA+             (PAVIA+PRIN)
MUSGRAVE 75 NP B87 365           +PEETERS,SCREINER,WHITMORE,YUTA          (ANL)
STRACHMA 75 NP B98 120           STRACHMAN, BRAUN, GERBER,MAURER+  (LPNP+STRB)I
WEBB     75 PL 55B 331           +TRILLING,TELEGDI+       (AACH+UCLA+UCR+CERN)
    ALSO 75 PL 55B 336           +TRILLING,TELEGDI+       (AACH+UCLA+UCR+CERN)

ATHERTON 76 NP B103 381          ATHERTON,FRENCH,SKURA,BOHM+        (CERN+PRAG)
BAKSAY   76 PL 61B 405           +BOHM,CHANG,ELLIS,FOETH+     (AACH+UCR+CERN)I

APPLE    77 LNC 18 167           +ASH,CHENG,COYNE,GROSSMAN+         (PRIN+PAVIA)
HEINEN   77 NP B122 443          +ENGELEN,KITTEL,METZGER+   (NIJM+AMST+CERN)IJP
ROUGE    77 PL 69B 115           +DE ROSNY,FLEURY,RIVET+     (LPNP+CDEF+LALO)IJP

EKELOF   78 NP B132 212          +HERZ,HAGBERG,KULLANDER+    (CERN+UPPS+LOUC)IJ
FERRER   78 NP B142 77           +BOUQUET,D.ALMAGNE+   (LALO+CERN+CDEF+EPOL)IJP
GODDARD  78 NP B134 49           +KEY,GORDON,LAI                    (TNTO+BNL)IJ
    ALSO 78 NP B138 265          +KEY,GORDON,LAI                    (TNTO+BNL)IJ
OTTER    78 NP B139 365          +RUDOLPH+          (AACH+BERL+CERN+LOIC+VIEN)IJP
APELDOOR 79 NP B156 111          VAN APELDOORN,HARTING,HCLTHUIZEN+      (AMST)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

MERLO    66 P ROY SOC 289 489 J P MERLO, G VALLADAS                   (SACLAY)
LISSAUER 72 PRD 6 1852           +FIRESTONE,GINESTET,GOLDHABER,TRILLING(LBL)IJP
ANTIPOV  75 NP B99 189           +ASCOLI,BAUD+          (CERN-IHEP BOSON SPEC)
LEDNICKY 75 PL 58B 89            R. LEDNICKY                            (JINR)
CARNEY   76 NP B110 248          +COLLEY,JONES,KENYON+ (BIRM+BRUX+CERN+MCNS)IJP
DEKERRET 76 PL 63B 477,483       +NAGY,REGLER,BRANDT+    (CERN+HAMB+IPN+VIEN)
RUSHBROO 76 PRD 13 1835          RUSHBROOKE,RAJA,ANSORGE,CARTER,NEALE (CAVE)IJP
SOTIRIOU 76 NP B107 457          D.SOTIRIOU                             (CERN)IJP

BACON    77 NC 42A 431           +BARNHAM,DORNAN,EASON,POLLOCK+         (LCIC)IJP
HARRIS   77 NP B119 189          +LUBATTI,MORIYASU,BINGHAM+          (WASH+UCB)
HOFMANN  77 NP B125 404          +IDSCHOK,SCHRODER,BLOBEL+  (BONN+DESY+MPIM)I
BIEL     78 PRD 18 3079          +FERBEL,SLATTERY+         (ROCH+NWES+FNAL+SLAC)
    ALSO 76 PRL 36 504,507       BIEL,BLESER,FERBEL+       (ROCH+FNAL+SLAC+NWES)
CHADWICK 78 PRD 17 1713          +CARROLL,CHALOUPKA,BALLAM+    (SLAC+CIT+LBL)IJP
GOGGI1   78 PL 79B 165           +CAVALLI-SFORZA,CONTA+              (CERN+PAVI)
    ALSO 77 PL 72B 261           GOGGI,MANTOVANI,CAVALLI-SFORZA+ (CERN+PAVI)
GOGGI2   78 NP B143 365          +CAVALLI-SFORZA,CONTA+              (CERN+PAVI)
IDSCHOK  78 NC 48A 395           +SCHRODER,BLOBEL,FRANZ+     (BONN+HAMB+MPIM)IJP
    ALSO 75 BLOBEL
MUHLEMAN 78 NP B133 189          MUHLEMANN,CARITHERS,FERBEL,LAM+ (ROCH+MCGI)
BAKKEN   79 NC 49A 465           +JACOBSEN,GENNOW+         (OSLO+STOH+HELS+ABO)
GOGGI    79 NP B161 14           +CONTA,FRATERNALI,LIVAN+   (CERN+PAVI+TRST)
LUCAS    79 PRD 19 43            P.W.LUCAS                               (JHU)
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N(1710)

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14  N*1/2(1710, JP=1/2+) I=1/2
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P''_{11}

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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               14  N*1/2(1710) MASS (MEV)

M   3     (1751.0)                       DONNACH1  68 RVUE   PHASE-SHIFT ANAL  8/69
M         (1640.0)   (70.0)              ORITO     69 RVUE   K LAMBDA PS ANAL  8/69
M         (1700.0)                       ORITO2    69 CNTR   K LAM PHOTOPRO   10/71
M   6     (1645.0)                       AYED      70 IPWA                     1/71
M   6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   4     (1770.0)                       DAVIES    70 RVUE   P-S ANAL   SOL A  8/69
M         (1809.0)                       SCHORSCH  70 DPWA   K LAM PHOTOPRO.  10/71
M   A     (1685.0)OR(1740.0)             WAGNER    71 IPWA   PI-P TO K LAMB    1/71
M   A   THERE ARE 3 SIMILAR SOLUTIONS
M   7     (1720.)                        ALMEHED   72 IPWA                     2/72
M    2    (1728.)                        HICKS     73 MPWA   GAM P-ETA P       9/73
M    2  ONLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS.        9/73
M    2  M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII.       9/73
M   F     (1780.)                        LANGBEIN  73 IPWA   PI N-K SIG,SOL 1  9/73
M   F     (1780.)                        LANGBEIN  73 IPWA   PI N-K SIG,SOL 2  9/73
M   F   DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF        1/78
M   F   WINNIK77 AROUND 1920 MEV.                                              1/78
M         (1670.)                        KNASEL    75 DPWA  0 PI- P TO KO LAM 11/75
M    K      1730. OR 1710.               LONGACRE  75 IPWA   PI N TO 2PI N    11/75
M    K  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.     11/75
M         (1730.)                        AYED      76 IPWA                    11/77
M   D     (1625.)    (10.)               BAKER     77 IPWA  0 PI- P TO K LAM.  1/78
M   E     (1650.)                        BAKER     77 DPWA  0 PI- P TO K LAM.  1/78
M   D   THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET        1/78
M   E   ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.              1/78
M   8     (1720.)                        LONGACRE  77 IPWA   PI N TO 2PI N    11/77
M   8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M   8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                           11/77
M           1650. TO 1680.               BAKER     78 DPWA  0 PI- P TO K LAM   3/79*
M    9    (1721.)                        BARBOUR   78 DPWA   PI-N PHOTO-PROD   3/79*
M         (1690.)                        BAKER     79 DPWA  0 PI- P TO ETA N  12/79*
M           1710.        60.             CUTKOSKY  79 IPWA   PI N TO PI N     12/79*
M    L      1723.         9.             HOEHLER   79 IPWA   PI N TO PI N     12/79*
M    H      2050.        20.             HOEHLER   79 IPWA   PI N TO PI N     12/79*
M   LH  HOEHLER79 FINDS A HIGHER MASS P11 RESONANCE, AS WELL AS ONE IN THIS 12/79*
M   LH  MASS REGION. BOTH ARE LISTED HERE, AND LABLED L AND H FOR LOW AND   12/79*
M   LH  HIGH, AWAITING CONFIRMATION OF THE HIGHER MASS STATE.               12/79*
M   C     (1730.)                        SAXON     80 DPWA  0 PI- P TO K LAM  12/79*
M           . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR =14.9)

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Data Card Listings

For notation, see key at front of Listings.

Baryons
N(1710)

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              14  N*1/2(1710) WIDTH (MEV)

W    3       (327.0)                       DONNACH1   68 RVUE                        8/69
W            (310.0)    (50.0)             ORITO      69 RVUE                        8/69
W            (210.0)                       ORITO2     69 CNTR    K LAM PHOTOPRO     10/71
W    6       (50.0)                        AYED       70 IPWA                        1/71
W    4       (445.0)                       DAVIES     70 RVUE    SOL A               8/69
W            (280.0)                       SCHORSCH   70 DPWA    K LAM PHOTOPRO.    10/71
W    A       (160.0)OR(220.0)              WAGNER     71 IPWA    PI-P TO K LAMB      1/71
W    7       (160.)                        ALMEHED    72 IPWA                        2/72
W    2       (203.)                        HICKS      73 MPWA    GAM P-ETA P         9/73
W    F       (130.)                        LANGBEIN   73 IPWA    PI N-K SIG,SOL 1    9/73
W    F       (130.)                        LANGBEIN   73 IPWA    PI N-K SIG,SOL 2    9/73
W            (174.)                        KNASEL     75 DPWA  O PI- P TO KO LAM    11/75
W    K       (165.) OR (75.)               LONGACRE   75 IPWA    PI N TO 2PI N      11/75
W            (164.)                        AYED       76 IPWA                       11/77
W    D       (160.)     (6.)               BAKER      77 IPWA  O PI- P TO K LAM.     1/78
W    E       (95.)                         BAKER      77 DPWA  O PI- P TO K LAM.     1/78
W    8       (120.)                        LONGACRE   77 IPWA    PI N TO 2PI N      11/77
W             90. TO  150.                 BAKER      78 DPWA  O PI- P TO K LAM     3/79*
W    9       (167.)                        BARBOUR    78 DPWA    PI-N PHOTO-PROD    3/79*
W            (97.)                         BAKER      79 DPWA  O PI- P TO ETA N    12/79*
W             100.        50.              CUTKOSKY   79 IPWA    PI N TO PI N      12/79*
W    L        120.        15.              HOEHLER    79 IPWA    PI N TO PI N      12/79*
W    H        200.        30.              HOEHLER    79 IPWA    PI N TO PI N      12/79*
W    C       (550.)                        SAXON      80 DPWA  O PI- P TO K LAM    12/79*
W             . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.8)
         SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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              14  N*1/2(1710) REAL PART OF POLE POSITION (MEV)                  11/75

RE           (1708.)                       LONGACRE   75 IPWA    PI N TO 2PI N      11/75
RE   8        1720. OR 1711.               LONGACRE   77 IPWA    PI N TO 2PI N      11/77
RE           (1692.)                       CUTKOSKY   79 IPWA    PI N TO PI N      12/79*

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              14  N*1/2(1710) -2*IMAG PART OF POLE POSITION (MEV)               11/75

IM           (17.)                         LONGACRE   75 IPWA    PI N TO 2PI N      11/75
IM   8        123. OR 115.                 LONGACRE   77 IPWA    PI N TO 2PI N      11/77
IM           (88.)                         CUTKOSKY   79 IPWA    PI N TO PI N      12/79*

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              14  N*1/2(1710) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          (-9.)                         CUTKOSKY   79 IPWA    PI N TO PI N      12/79*

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              14  N*1/2(1710) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR           (.1)                         CUTKOSKY   79 IPWA    PI N TO PI N      12/79*

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              14  N*1/2(1710) PARTIAL DECAY MODES

                                                               DECAY MASSES
P1      N*1/2(1710) INTO PI N                                  139+ 938
P2      N*1/2(1710) INTO LAMBDA K                             1115+ 497
P3      N*1/2(1710) INTO N ETA                                 939+ 548
P4      N*1/2(1710) INTO GAM P, HELICITY=1/2                     0+ 938
P5      N*1/2(1710) INTO GAM N, HELICITY=1/2                     0+ 939
P6      N*1/2(1710) INTO N PI PI                               938+ 139+ 139
P7      N*1/2(1710) INTO N EPSILON                             938+1300
P8      N*1/2(1710) INTO N RHO                                 938+ 776
P9      N*1/2(1710) INTO K SIGMA                               493+1189
P10     N*1/2(1710) INTO N*3/2(1232) PI                       1232+ 139
P11     N*1/2(1710) INTO N RHO,S=1/2,P-WAVE                    938+ 776
P12     N*1/2(1710) INTO N RHO,S=3/2,P-WAVE                    938+ 776

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              14  N*1/2(1710) BRANCHING RATIOS

R1      N*1/2(1710) INTO (PI N)/TOTAL                         (P1)
R1   3       (0.32)                        DONNACH1   68 RVUE                        8/69
R1   6       (0.149)                       AYED       70 IPWA                        1/71
R1   4       (0.43)                        DAVIES     70 RVUE    SOL A               8/69
R1   7       (0.2)                         ALMEHED    72 IPWA                        2/72
R1            (.17)                        AYED       76 IPWA                       11/77
R1             .19        .05              CUTKOSKY   79 IPWA    PI N TO PI N      12/79*
R1   L         .12        .04              HOEHLER    79 IPWA    PI N TO PI N      12/79*
R1   H         .10        .04              HOEHLER    79 IPWA    PI N TO PI N      12/79*
R1            . . . . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R2      N*1/2(1710) FROM PI N TO K LAMBDA                  SQRT(P1*P2)               4/75
R2           (.06)      (.03)              ORITO      69 RVUE                        4/75
R2   A       (.16)OR .21                   WAGNER     71         PI- P TO K LAMB     4/75
R2           -.150       .038              DEVENISH   74       O FIXED T DISP REL    4/75
R2           (.10)                         KNASEL     75 DPWA  O PI- P TO KO LAM    11/75
R2   D       (-.05)     (.03)              BAKER      77 IPWA  O PI- P TO K LAM.     1/78
R2   E       (-.10)                        BAKER      77 DPWA  O PI- P TO K LAM.     1/78
R2   9       (-.12)                        BAKER      78 DPWA  O PI- P TO K LAM     3/79*
R2   9  THE (UNDETERMINED) OVERALL PHASE OF ALL COUPLINGS FROM BAKER78               3/79*
R2   9  HAS BEEN CHANGED TO AGREE WITH PREVIOUS CONVENTIONS.                         3/79*
R2   C       (+.14)                        SAXON      80 DPWA  O PI- P TO K LAM    12/79*
R2   C  SUPERSEDES BAKER 78.                                                        12/79*

R3      N*1/2(1710) INTO (LAMBDA K)/TOTAL                     (P2)
R3   B       (0.003)TO 0.065               RUSH       68 MPWA    T POLE + RESON.     8/69
R3   B  PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R4      N*1/2(1710) INTO (N ETA)/TOTAL                        (P3)
R4   B       (0.19)                        BOTKE      69 MPWA    T POLE + RESON.    10/69
R4   B       (0.09)     (0.05)             DEANS      69 MPWA    T POLE + RESON.     5/70
R4   B       (0.015)OR 0.035               CARRERAS   70 MPWA    T POLE + RESON.     5/70
R4   B  PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R5      N*1/2(1710) FROM GAMMA PROTON TO K LAMBDA          SQRT(P2*P4)               9/73
R5           (0.0027)                      ORITO2     69 CNTR    K LAM PHOTOPRO     10/71
R5           (0.0088)                      SCHORSCH   70 DPWA    K LAM PHOTOPRO.    10/71
R5           (.0104)                       DEANS      72 MPWA    GAM P-K LM,SOL D    9/73

R6      N*1/2(1710) FROM GAMMA PROTON TO ETA PROTON        SQRT(P3*P4)               9/73
R6   2       (.0075)                       HICKS      73 MPWA    GAM P-ETA P         9/73

R7      N*1/2(1710) FROM PI N TO K SIGMA                   SQRT(P1*P9)               9/73
R7   F        (.11)                        LANGBEIN   73 IPWA    PI N-K SIG,SOL 1    9/73
R7   F        (.14)                        LANGBEIN   73 IPWA    PI N-K SIG,SOL 2    9/73
R7   1        (.075)TO  .203               DEANS      75 DPWA    PI N TO K SIGMA    11/75
R7   1  RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                                    11/75

R8      N*1/2(1710) FROM PI N TO N*3/2(1232) PI            SQRT(P1*P10)             11/75
R8   K        (.13)OR  -.20                LONGACRE   75 IPWA    PI N TO 2PI N      11/75
R8   8        (+.17)                       LONGACRE   77 IPWA    PI N TO 2PI N      11/77

R9      N*1/2(1710) FROM PI N TO N RHO,S=1/2,P-WAVE        SQRT(P1*P11)             11/75
R9   K        (+.32)OR  +.20               LONGACRE   75 IPWA    PI N TO 2PI N      11/75
R9   8        (-.19)                       LONGACRE   77 IPWA    PI N TO 2PI N      11/77

R10     N*1/2(1710) FROM PI N TO N RHO,S=3/2,P-WAVE        SQRT(P1*P12)             11/77
R10  8        (-.31)                       LONGACRE   77 IPWA    PI N TO 2PI N      11/77

R11     N*1/2(1710) FROM PI N TO N EPSILON                 SQRT(P1*P7)              11/75
R11  K        (+.18)OR  +.28               LONGACRE   75 IPWA    PI N TO 2PI N      11/75
R11  8        (+.26)                       LONGACRE   77 IPWA    PI N TO 2PI N      11/77

R12     N*1/2(1710) FROM PI N TO ETA N                     SQRT(P1*P3)              11/75
R12  5        (+.382)TO +.383              FELTESSE   75 DPWA  0 1488 TO 1745 MEV   11/75
R12  5  USES M AND W OF AYED 76.  NOTE THAT THIS GIVES A BRANCHING                  11/77
R12  5  RATIO TO ETA N OF ABOUT 80 PCT, IN STRONG DISAGREEMENT WITH                 11/75
R12  5  EARLIER EXPERIMENTS.                                                        11/75
R12           (.22)                        BAKER      79 DPWA  O PI- P TO ETA N    12/79*

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              14  N*1/2(1710) PHOTON DECAY AMPL(GEV**-1/2)

    FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*1/2(1710) INTO GAM P, HELICITY=1/2 (GEV**-1/2)
A1             .022       .057             DEVENISH   73 DPWA    PI N PHOTO PROD     2/74
A1            +.026       .028             MOORHOUS   73 DPWA    PI N PHOTO-PROD     2/73
A1            -.014       .021             DEVENIS2   74 DPWA    PI N PHOTO-PROD     4/75
A1             .022       .015             KNIES      74 DPWA    PI N PHOTO PROD     2/74
A1            -.068       .024             METCALF    74 DPWA    PI N PHOTO-PROD     2/74
A1             .016       .025             MOORHOUS   74 DPWA    PI N PHOTO-PROD     2/74
A1            +.062       .007             CRAWFORD   75 DPWA    PI N PHOTO-PROD     1/76
A1           (+.005)                       BARBOUR    76 DPWA    PI N PHOTO-PROD     1/76
A1            +.053       .019             FELLER     76 DPWA    PI N PHOTO-PROD     2/77
A1   9        +.001       .039             BARBOUR    78 DPWA    PI-N PHOTO-PROD    3/79*
A1   9  SUPERSEDES BARBOUR 76.                                                       3/79*
A1            . . . . . . . . .
A1   AVERAGE MEANINGLESS (SCALE FACTOR = 2.4)

A2      N*1/2(1710) INTO GAM N, HELICITY=1/2 (GEV**-1/2)
A2            -.028       .067             DEVENISH   73 DPWA    PI N PHOTO PROD     2/74
A2            +.027       .022             MOORHOUS   73 DPWA    PI N PHOTO-PROD     2/73
A2            -.060       .061             DEVENIS2   74 DPWA    PI N PHOTO-PROD     4/75
A2             .027       .015             KNIES      74 DPWA    PI N PHOTO PROD     2/74
A2             .048       .045             METCALF    74 DPWA    PI N PHOTO-PROD     2/74
A2             .057       .022             MOORHOUS   74 DPWA    PI N PHOTO-PROD     2/74
A2            -.020       .016             CRAWFORD   75 DPWA    PI N PHOTO-PROD     1/76
A2           (-.010)                       BARBOUR    76 DPWA    PI N PHOTO-PROD     1/76
A2   9        -.028       .045             BARBOUR    78 DPWA    PI-N PHOTO-PROD    3/79*
A2            . . . . . . . . .
A2   AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

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REFERENCES FOR N*1/2(1710)


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DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                           (EDIN)
RUSH     68 PR 173 1776        J E RUSH                     (UNIV ALABAMA)

BOTKE    69 PR 180 1417        J C BOTKE                             (UCSB)
DEANS    69 PR 185 1797        S DEANS, J WOOTEN          (UNIV S FLORIDA)
ORITO    69 LNC 1 936          S ORITO,S SASAKI              (TOKYO-OSAKA)
ORITO2   69 INS J 113          S ORITO (THESIS)                     (TOKYO)

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET         (SACL)IJP
CARRERAS 70 NP 16B 35          B CARRERAS, A DONNACHIE        (DARE,MCHS)
DAVIES   70 NP B21 359         A DAVIES                              (GLAS)
SCHORSCH 70 NP  B25 179        +TIETGE,WEILNBOECK                    (MPIM)

WAGNER   71 NP B25 411         F WAGNER, C LOVELACE                  (CERN)

ALMEHED  72 NP B40 157         +LOVELACE                   (LUND,RUTG)IJP
DEANS    72 PRD 6 1906         DEANS,JACOBS, LYONS,MONTGOMERY (SOUTH FLA.)IJP

DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH      (LOUC+BONN+LANC)IJP
HICKS    73 PRD 7 2614         +DEANS,JACOBS,LYONS+ (CARN+ORNL+SOUTH FLA.)IJP
LANGBEIN 73 NP B53 251         LANGBEIN,WAGNER                  (MUNICH)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK            (GLAS+LBL)IJP

DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LCUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN     (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680         KNIES,MOORHOUSE,OBERLACK       (LBL,GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER              (CIT)IJP
MOORHOUS 74 PRD 9 1            MOORHOUSE,OBERLACK,ROSENFELD   (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                       (GLAS)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+     (SFLA,ALABAMA)IJP
FELTESSE 75 NP B93 242         +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KNASEL   75 PRD 11 1           +LINDQUIST,NELSON+      (CHIC,WUSL,OSU,ANL)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+    (LBL,SLAC)IJP
    ALSO 78 PRD 17 1795        LONGACRE,LASINSKI,ROSENFELD+      (LBL,SLAC)

AYED     76 CEA-N-1921         AYED (THESIS)                      (SACL)IJP
BARBOUR  76 NP B111 358        I. M. BARBOUR,R. L. CRAWFORD       (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP
BAKER    77 NP B126 365        +BLISSET,BLOODWORTH,BROOME,HART+   (RHEL)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                   (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET      (SACL)IJP

BAKER    78 NP B141 29         +BLISSET,BLOODWORTH,BROOME+     (RL+CAMB)IJP
BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS             (GLAS)

BAKER    79 NP B156 93         +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PRD 20 2839        +FORSYTH,HENDRICK,KELLY        (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN         /KARLSRUHE IJP
SAXON    80 NP B162 522        +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
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Baryons
N(1710), N(1810)

Data Card Listings
For notation, see key at front of Listings.

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                      PAPERS NOT REFERRED TO IN DATA CARDS

DEANS     69 PR  177 2623     S R DEANS                        (UNIV S FLORIDA)
DONNACHI  69 NP 10B 433       A DONNACHIE, R KIRSOPP               (GLAS+EDIN)
AYED      70 PL 31B 598       +BAREYRE+VILLET                         (SACLAY)
WINNIK    77 NP B128 66       +TOAFF,REVEL,GOLDBERG,BERNY              (HAIF)I

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N(1810) P''13

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15  N*1/2(1810, JP=3/2+) I=1/2
THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                15  N*1/2(1810) MASS (MEV)

M   3    (1860.0)                    DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M   X    (1860.0)       APPROX       LEA       69 CNTR    PI-P ELASTIC      8/69
M   X  SEE ALSO APLIN 71
M   6    (1766.0)                    AYED      70 IPWA                      1/71
M   6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   4    (1844.0)                    DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M   A    (1800.0)                    WAGNER    71 IPWA    PI-P TO K LAMB    1/71
M   A  P13 RESONATES ONLY IN ONE OUT OF 3 POSSIBLE SOLUTIONS
M   7    (1850.)                     ALMEHED   72 IPWA                      2/72
M    1   (1833.)                     HICKS     73 MPWA    GAM P-ETA P       9/73
M    1  CNLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS.     9/73
M    1  M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII.    9/73
M        (1850.)                     KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
M    L     1695. OR 1720.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M        (1696.)                     AYED      76 IPWA                     11/77
M   D    (1640.)     (10.)           BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
M   E    (1710.)                     BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
M   D   THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET     1/78
M   E   ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.           1/78
M   8    (1750.)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M   8   ALL LONGACRE77 PARAMETERS ARE FRCM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M   8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                        11/77
M          1710. TO 1790.            BAKER     78 DPWA  0 PI- P TO K LAM    3/79*
M    5   (1809.)                     BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
M          1740.       80.           CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
M          1710.       20.           HOEHLER   79 IPWA    PI N TO PI N     12/79*
M   C    (1690.)                     SAXON     80 DPWA  0 PI- P TO K LAM   12/79*
M          . . . . . . . . . .
M  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                15  N*1/2(1810) WIDTH (MEV)

W   3    (296.00)                    DONNACH1  68 RVUE                      8/69
W   6    (182.0)                     AYED      70 IPWA                      1/71
W   4    (449.0)                     DAVIES    70 RVUE    SOL A             8/69
W   4  SOL B GIVES 307 MEV                                                  2/73
W   A    (220.0)                     WAGNER    71 IPWA    PI-P TO K LAMB    1/71
W   7    (300.)                      ALMEHED   72 IPWA                      2/72
W    1   (250.)                      HICKS     73 MPWA    GAM P-ETA P       9/73
W        (327.)                      KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
W    L     115. OR  150.             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W        (117.)                      AYED      76 IPWA                     11/77
W   D    (200.)     (50.)            BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
W   E    (500.)                      BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
W   8    (130.)                      LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W          300. TO  400.             BAKER     78 DPWA  0 PI- P TO K LAM    3/79*
W    5   (285.)                      BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
W        (447.)                      BAKER     79 DPWA  0 PI- P TO ETA N   12/79*
W          210.       80.            CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
W          190.       30.            HOEHLER   79 IPWA    PI N TO PI N     12/79*
W   C    (120.)                      SAXON     80 DPWA  0 PI- P TO K LAM   12/79*
W          . . . . . . . . . .
W  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
             SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                15  N*1/2(1810) REAL PART OF PCLE POSITION (MEV)       11/75

RE       (1716.)                     LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE  8      1745. OR 1748.            LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE       (1702.)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                15  N*1/2(1810) -2*IMAG PART OF PCLE POSITICN (MEV)    11/75

IM       (124.)                      LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM  8      135. OR 123.              LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM       (158.)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                15  N*1/2(1810) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER       (-6.)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                15  N*1/2(1810) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR       (-8.)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                15  N*1/2(1810) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1      N*1/2(1810) INTO PI N                        139+ 938
P2      N*1/2(1810) INTO LAMBDA K                   1115+ 497
P3      N*1/2(1810) INTO N ETA                       939+ 548
P4      N*1/2(1810) INTO N PI PI                     938+ 139+ 139
P5      N*1/2(1810) INTO GAM P,HELICITY=3/2            0+ 938
P6      N*1/2(1810) INTO GAM P,HELICITY=1/2            0+ 938
P7      N*1/2(1810) INTO GAM N,HELICITY=3/2            0+ 939
P8      N*1/2(1810) INTO GAM N,HELICITY=1/2            0+ 939
P9      N*1/2(1810) INTO SIGMA K                     493+1189
P10     N*1/2(1810) INTO N RHO,S=1/2,P-WAVE          938+ 776
P11     N*1/2(1810) INTO N RHO,S=3/2,P-WAVE          938+ 776
P12     N*1/2(1810) INTO N*3/2(1232) PI,P-WAVE      1232+ 139
P13     N*1/2(1810) INTO N EPSILON                   938+1300

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                15  N*1/2(1810) BRANCHING RATIOS

R1      N*1/2(1810) INTO (PI N)/TOTAL                        (P1)
R1  3       (0.21)                   DONNACH1  68 RVUE                      8/69
R1  6       (0.149)                  AYED      70 IPWA                      1/71
R1  4       (0.40)                   DAVIES    70 RVUE    SOL A             8/69
R1  7       (0.25)                   ALMEHED   72 IPWA                      2/72
R1           (.14)                   AYED      76 IPWA                     11/77
R1            .19       .05          CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
R1            .14       .03          HOEHLER   79 IPWA    PI N TO PI N     12/79*
R1          . . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R2      N*1/2(1810) INTO (LAMBDA K)/TOTAL                    (P2)
R2  B       (0.014)TO 0.16           RUSH      68 MPWA     T POLE + RESON.  8/69
R2  B    PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R3      N*1/2(1810) INTO (N ETA)/TOTAL                       (P3)
R3  B       (0.0364)                 BOTKE     69 MPWA     T POLE + RESON. 10/69
R3  B       (0.003)  (0.003)         DEANS     69 MPWA     T POLE + RESON.  5/70
R3  B       (0.030)OR 0.094          CARRERAS  70 MPWA     T POLE + RESON.  5/70
R3  B    PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R4      N*1/2(1810) FROM PI N TO K LAMBDA                    SQRT(P1*P2)        4/75
R4  A       (.12)                    WAGNER    71 IPWA     PI- P TO K LAMB  4/75
R4           -.067      .033         DEVENISH  74           0 FIXED T DISP REL  4/75
R4           (.13)                   KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
R4  D       (-.06)    (.02)          BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
R4  E       (-.09)                   BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
R4   9      (-.09)                   BAKER     78 DPWA  0 PI- P TO K LAM    3/79*
R4   9   THE (UNDETERMINED) OVERALL PHASE OF ALL COUPLINGS FROM BAKER78     3/79*
R4   9   HAS BEEN CHANGED TO AGREE WITH PREVIOUS CONVENTIONS.               3/79*
R4  C       (-.11)                   SAXON     80 DPWA  0 PI- P TO K LAM   12/79*
R4  C    SUPERSEDES BAKER 78.                                              12/79*

R5      N*1/2(1810) FROM GAMMA PROTON TO K LAMBDA            SQRT((P5+P6)*P2)   9/73
R5          (.0082)                  DEANS     72 MPWA     GAM P-K LM,SOL D 9/73

R6      N*1/2(1810) FROM GAMMA PROTON TO ETA PROTON          SQRT((P5+P6)*P3)   9/73
R6   1      (.0052)                  HICKS     73 MPWA     GAM P-ETA P      9/73

R7      N*1/2(1810) FROM PI N TO K SIGMA                     SQRT(P1*P9)       11/75
R7  2       (.051)TO  .087           DEANS     75 DPWA     PI N TO K SIGMA 11/75
R7  2    RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                          11/75
R7  2    DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77         1/78
R7  2    AROUND 1920 MEV.                                                   1/78

R8      N*1/2(1810) FROM PI N TO N RHO,S=1/2,P-WAVE          SQRT(P1*P10)      11/75
R8   L      (-.35)OR  -.40           LONGACRE  75 IPWA     PI N TO 2PI N   11/75
R8  8       (+.26)                   LONGACRE  77 IPWA     PI N TO 2PI N   11/77

R9      N*1/2(1810) FROM PI N TO N RHO,S=3/2,P-WAVE          SQRT(P1*P11)      11/77
R9  8       (-.15)                   LONGACRE  77 IPWA     PI N TO 2PI N   11/77

R10     N*1/2(1810) FROM PI N TO N*3/2(1232)PI,P-WAVE        SQRT(P1*P12)      11/77
R10 8       (+.17)                   LONGACRE  77 IPWA     PI N TO 2PI N   11/77

R11     N*1/2(1810) FROM PI N TO N EPSILON                   SQRT(P1*P13)      11/77
R11 8       (+.19)                   LONGACRE  77 IPWA     PI N TO 2PI N   11/77

R12     N*1/2(1810) FROM PI N TO ETA N                       SQRT(P1*P3)       12/79*
R12         (-.08)                   BAKER     79 DPWA  0 PI- P TO ETA N   12/79*

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                15  N*1/2(1810) PHOTON DECAY AMPL(GEV**-1/2)

     FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
   REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*1/2(1810) INTO GAM P, HELICITY=1/2  (GEV**-1/2)
A1           -.022      .094         DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A1            .025      .034         DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A1           -.004      .032         KNIES     74 DPWA    PI N PHOTO PROD    2/74
A1            .0        .025         METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A1           +.022      .012         CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A1          (+.086)                  BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A1           +.122      .018         AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79*
A1           +.054      .012         AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79*
A1  5        +.111      .047         BARBOUR   78 DPWA    PI-N PHOTO-PROD    3/79*
A1  5    SUPERSEDES BARBOUR 76.                                             3/79*
A1          . . . . . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)

A2      N*1/2(1810) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2           -.001      .106         DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A2           -.087      .057         DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A2           -.006      .030         KNIES     74 DPWA    PI N PHOTO PROD    2/74
A2            .0        .022         METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A2           -.016      .016         CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A2          (-.060)                  BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A2           +.034      .015         AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79*
A2            .000      .016         AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79*
A2  5        -.063      .032         BARBOUR   78 DPWA    PI-N PHOTO-PROD    3/79*
A2          . . . . . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

A3      N*1/2(1810) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3            .132      .173         DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A3            .013      .045         DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A3            .014      .014         KNIES     74 DPWA    PI N PHOTO PROD    2/74
A3            .0        .050         METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A3           -.037      .022         CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A3          (-.020)                  BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A3  5        +.007      .020         BARBOUR   78 DPWA    PI-N PHOTO-PROD    3/79*
A3          . . . . . . . . . .
A3  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

A4      N*1/2(1810) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4            .080      .133         DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A4           -.083      .090         DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A4           -.008      .025         KNIES     74 DPWA    PI N PHOTO PROD    2/74
A4            .0        .044         METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A4           -.038      .015         CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A4          (+.046)                  BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A4  5        +.051      .051         BARBOUR   78 DPWA    PI-N PHOTO-PROD    3/79*
A4          . . . . . . . . . .
A4  AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

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Data Card Listings

For notation, see key at front of Listings.

Baryons
N(1810), N(1990)

REFERENCES FOR N*1/2(1810)

DONNACHI1 68 PL 26B 161 A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
ALSO 68 VIENNA 139 DONNACHIE RAPPORTEUR.S TALK (GLAS)
ALSO 68 THESIS R G KIRSOPP (EDIN)
RUSH 68 PR 173 1776 J E RUSH (UNIV ALABAMA)

BOTKE 69 PR 180 1417 J C BOTKE (UCSB)
DEANS 69 PR 185 1797 S DEANS, J WOOTEN (UNIV S FLORIDA)
LEA 69 PL 29B 584 LEA,OADES,WARD,COWAN,+ (RHEL,BRISTOL,DARE)

AYED 70 KIEV CONF R AYED,P BAREYRE, G VILLET (SACL)IJP
CARRERAS 70 NP 16B 35 B CARRERAS, A DONNACHIE (DARE,MCHS)
DAVIES 70 NP B21 359 A DAVIES (GLAS)

WAGNER 71 NP B25 411 F WAGNER, C LOVELACE (CERN)

ALMEHED 72 NP B40 157 +LOVELACE (LUND,RUTG)IJP
DEANS 72 PRD 6 1906 DEANS,JACOBS, LYONS,MONTGOMERY (SOUTH FLA.)IJP
DEVENISH 73 PL 47B 53 DEVENISH,RANKIN,LYTH (LOUC+BONN+LANC)IJP
HICKS 73 PRD 7 2614 +DEANS,JACOBS,LYONS+ (CARN+ORNL+SOUTH FLA.)IJP

DEVENISH 74 NP B81 330 DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LCUC)
DEVENIS2 74 PL 52B 227 DEVENISH,LYTH,RANKIN (DESY,LANC,BONN)IJP
KNIES 74 PRD 9 2680 KNIES,MOORHOUSE,OBERLACK (LBL,GLAS)IJP
METCALF 74 NP B76 253 W J METCALF,R L WALKER (CIT)IJP

CRAWFORD 75 NP B97 125 R L CRAWFORD (GLAS)IJP
DEANS 75 NP B96 90 +MITCHELL,MONTGOMERY,+ (SFLA,ALABAMA)IJP
KNASEL 75 PRD 11 1 +LINDQUIST,NELSON+ (CHIC,WUSL,OSU,ANL)IJP
LONGACRE 75 PL 55B 415 +ROSENFELD,LASINSKI,SMADJA+ (LBL,SLAC)IJP
ALSO 78 PRD 17 1795 LONGACRE,LASINSKI,ROSENFELD+ (LBL,SLAC)

AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 I. M. BARBOUR,R. L. CRAWFORD (GLAS)IJP

AZNAURYA 77 EFI-264(57)-77 +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
BAKER 77 NP B126 365 +BLISSET,BLOODWORTH,BROOME,HART+ (RHEL)IJP
LONGACRE 77 NP B122 493 LONGACRE,DOLBEAU (SACL)IJP
ALSO 76 NP B108 365 DOLBEAU,TRIANTIS,NEVEU,CADIET (SACL)IJP

BAKER 78 NP B141 29 +BLISSET,BLOODWORTH,BROOME+ (RL+CAMB)IJP
BARBOUR 78 NP B141 253 BARBOUR,CRAWFORD,PARSONS (GLAS)

BAKER 79 NP B156 93 +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PRD 20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN /KARLSRUHE IJP
SAXON 80 NP B162 522 +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

PAPERS NOT REFERRED TO IN DATA CARDS

DEANS 69 PR 177 2623 S R DEANS (UNIV S FLORIDA)
DONNACHI 69 NP 10B 433 A DONNACHIE, R KIRSOPP (GLAS+EDIN)

AYED 70 PL 31B 598 +BAREYRE,VILLET (SACLAY)
APLIN 71 NP B32 253 +COWAN,GIBSON,GILMORE++ (RHEL,BRISTOL)
MA 76 PRD 13 3027 E. MA,G. L. SHAW (OREG+UCI)IJP
WINNIK 77 NP B128 66 +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I

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N(1990) 17 N*1/2(1990, JP=7/2+) I=1/2 F_{17}

17 N*1/2(1990) MASS (MEV)

M 3 (1983.0) DONNACHI1 68 RVUE PHASE-SHIFT ANAL
M 3 (1995.) KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69
M 3 WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1 10/69
M X (2000.0) APPROX LEA 69 CNTR PI-P ELASTIC 8/69
M X SEE ALSO APLIN 71
M 7 (2000.) ALMEHED 72 IPWA 2/72
M H (1970.) HICKS 73 MPWA GAM P-ETA P 9/73
M H ONLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS. 9/73
M H M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII. 9/73
M 1 (1960.) LANGBEIN 73 IPWA PI N-K SIG,SOL 1 9/73
M 1 NOT SEEN IN SOLUTION 2 OF LANGBEIN73 9/73
M 1 DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF 1/78
M 1 WINNIK77 AROUND 1920 MEV. 1/78
M (2049.) AYED 76 IPWA 11/77
M 4 (1999.) BARBOUR 78 DPWA PI-N PHOTO-PROD 3/79*
M 1970. 80. CUTKOSKY 79 IPWA PI N TO PI N 12/79*
M 2005. 150. HOEHLER 79 IPWA PI N TO PI N 12/79*
M . . . .
M AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

17 N*1/2(1990) WIDTH (MEV)

W 3 (225.0) DONNACHI1 68 RVUE 8/69
W 3 (250.) KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69
W 7 (200.) ALMEHED 72 IPWA 2/72
W H (300.) HICKS 73 MPWA GAM P-ETA P 9/73
W 1 (170.) LANGBEIN 73 IPWA PI N-K SIG,SOL 1 9/73
W (119.) AYED 76 IPWA 11/77
W 4 (216.) BARBOUR 78 DPWA PI-N PHOTO-PROD 3/79*
W 325. 150. CUTKOSKY 79 IPWA PI N TO PI N 12/79*
W 350. 100. HOEHLER 79 IPWA PI N TO PI N 12/79*
W . . . .
W AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

17 N*1/2(1990) REAL PART OF POLE POSITION (MEV)

REE (1899.) CUTKOSKY 79 IPWA PI N TO PI N 12/79*

17 N*1/2(1990) -2*IMAG PART OF POLE POSITION (MEV)

IME (208.) CUTKOSKY 79 IPWA PI N TO PI N 12/79*

17 N*1/2(1990) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER (3.) CUTKOSKY 79 IPWA PI N TO PI N 12/79*

17 N*1/2(1990) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR (-6.) CUTKOSKY 79 IPWA PI N TO PI N 12/79*

17 N*1/2(1990) PARTIAL DECAY MODES

		DECAY MASSES
P1	N*1/2(1990) INTO PI N	139+ 938
P2	N*1/2(1990) INTO N PI PI	938+ 139+ 139
P3	N*1/2(1990) INTO N ETA	939+ 548
P4	N*1/2(1990) INTO LAMBDA K	1115+ 497
P5	N*1/2(1990) INTO GAM P,HELICITY=3/2	0+ 938
P6	N*1/2(1990) INTO GAM P,HELICITY=1/2	0+ 938
P7	N*1/2(1990) INTO GAM N,HELICITY=3/2	0+ 939
P8	N*1/2(1990) INTO GAM N,HELICITY=1/2	0+ 939
P9	N*1/2(1990) INTO K SIGMA	493+1189

17 N*1/2(1990) BRANCHING RATIOS

R1 N*1/2(1990) INTO (PI N)/TOTAL (P1)
R1 3 (.09) KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69
R1 7 (0.15) ALMEHED 72 IPWA 2/72
R1 (.06) AYED 76 IPWA 11/77
R1 .06 .02 CUTKOSKY 79 IPWA PI N TO PI N 12/79*
R1 .04 .02 HOEHLER 79 IPWA PI N TO PI N 12/79*
R1 . . . .
R1 AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R2 N*1/2(1990) INTO (N ETA)/TOTAL (P3)
R2 B (0.02) (0.02) DEANS 69 MPWA T POLE + RESON. 5/70
R2 B PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R3 N*1/2(1990) FROM GAMMA PROTON TO K LAMBDA SQRT((P5+P6)*P4) 9/73
R3 .0034 DEANS 72 MPWA GAM P-K LM,SOL D 9/73

R4 N*1/2(1990) FROM GAMMA PROTON TO ETA PROTON SQRT((P5+P6)*P3) 9/73
R4 H (.0045) HICKS 73 MPWA GAM P-ETA P 9/73

R5 N*1/2(1990) FROM PI N TO K SIGMA SQRT(P1*P9) 9/73
R5 1 (.06) LANGBEIN 73 IPWA PI N-K SIG,SOL 1 9/73
R5 2 (.010)TO .023 DEANS 75 DPWA PI N TO K SIGMA 11/75
R5 2 RANGE GIVEN IS FROM FOUR BEST SOLUTIONS. 11/75

R6 N*1/2(1990) FROM PI N TO K LAMBDA SQRT(P1*P4) 4/75
R6 -.021 .033 DEVENISH 74 0 FIXED T DISP REL 4/75
R6 NOT SEEN SAXON 80 DPWA 0 PI- P TO K LAM 12/79*

R7 N*1/2(1990) FROM PI N TO ETA N SQRT(P1*P3) 12/79*
R7 (-.043) BAKER 79 DPWA 0 PI- P TO ETA N 12/79*

17 N*1/2(1990) PHOTON DECAY AMPL(GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1 N*1/2(1990) INTO GAM P, HELICITY=1/2 (GEV**-1/2) 1/76
A1 (+.011) BARBOUR 76 DPWA PI N PHOTO-PROD 1/76
A1 4 (.040) BARBOUR 78 DPWA PI-N PHOTO-PROD 3/79*
A1 4 SUPERSEDES BARBOUR 76. 3/79*

A2 N*1/2(1990) INTO GAM P, HELICITY=3/2 (GEV**-1/2) 1/76
A2 (-.008) BARBOUR 76 DPWA PI N PHOTO-PROD 1/76
A2 4 (+.004) BARBOUR 78 DPWA PI-N PHOTO-PROD 3/79*

A3 N*1/2(1990) INTO GAM N, HELICITY=1/2 (GEV**-1/2) 1/76
A3 (-.099) BARBOUR 76 DPWA PI N PHOTO-PROD 1/76
A3 4 (-.069) BARBOUR 78 DPWA PI-N PHOTO-PROD 3/79*

A4 N*1/2(1990) INTO GAM N, HELICITY=3/2 (GEV**-1/2) 1/76
A4 (-.070) BARBOUR 76 DPWA PI N PHOTO-PROD 1/76
A4 4 (-.072) BARBOUR 78 DPWA PI-N PHOTO-PROD 3/79*

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REFERENCES FOR N*1/2(1990)

DONNACHI1 68 PL 26B 161 A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
KIRSOPP 68 THESIS R G KIRSOPP (EDIN)

DEANS 69 PR 185 1797 S DEANS, J WOOTEN (UNIV S FLORIDA)
LEA 69 PL 29B 584 LEA,OADES,WARD,COWAN,+ (RHEL,BRISTOL,DARE)

ALMEHED 72 NP B40 157 ,LOVELACE (RUTG)IJP
DEANS 72 PRD 6 1906 DEANS,JACOBS, LYONS,MONTGOMERY (SOUTH FLA.)IJP
HICKS 73 PRD 7 2614 +DEANS,JACOBS,LYONS+ (CARN+ORNL+SOUTH FLA.)IJP
LANGBEIN 73 NP B53 251 LANGBEIN,WAGNER (MUNICH)IJP

DEVENISH 74 NP B81 330 DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LCUC)
DEANS 75 NP B96 90 +MITCHELL,MONTGOMERY,+ (SFLA,ALABAMA)IJP

AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 I. M. BARBOUR,R. L. CRAWFORD (GLAS)IJP

BARBOUR 78 NP B141 253 BARBOUR,CRAWFORD,PARSONS (GLAS)

BAKER 79 NP B156 93 +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PRD 20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN /KARLSRUHE IJP
SAXON 80 NP B162 522 +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

PAPERS NOT REFERRED TO IN DATA CARDS

DEANS 69 PR 177 2623 S R DEANS (UNIV S FLORIDA)
AYED 70 PL 31B 598 +BAREYRE,VILLET (SACLAY)
APLIN 71 NP B32 253 +COWAN,GIBSON,GILMORE++ (RHEL,BRISTOL)
MA 76 PRD 13 3027 E. MA,G. L. SHAW (OREG+UCI)IJP
WINNIK 77 NP B128 66 +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I

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Baryons
N(2000), N(2040)

Data Card Listings
For notation, see key at front of Listings.

N(2000)

06 N*1/2(2000, JP=5/2+) I=1/2 F''_{15}

06 N*1/2(2000) MASS (MEV)

M	7	(2175.)		ALMEHED	72	IPWA		2/72
M		(1930.)		DEANS	72	MPWA	GAM P-K LM,SOL D	9/73
M	1	(1970.)		LANGBEIN	73	IPWA	PI N-K SIG,SOL 2	9/73
M	1	NOT SEEN IN SOLUTION 1 OF LANGBEIN73						9/73
M		(2025.)		AYED	76	IPWA		11/77
M		1882.	10.	HOEHLER	79	IPWA	PI N TO PI N	12/79*

06 N*1/2(2000) WIDTH (MEV)

W	7	(150.)		ALMEHED	72	IPWA		2/72
W		(112.)		DEANS	72	MPWA	GAM P-K LM,SOL D	9/73
W	1	(170.)		LANGBEIN	73	IPWA	PI N-K SIG,SOL 2	9/73
W		(157.)		AYED	76	IPWA		11/77
W		95.	20.	HOEHLER	79	IPWA	PI N TO PI N	12/79*

06 N*1/2(2000) PARTIAL DECAY MODES

		DECAY MASSES
P1	N*1/2(2000) INTO PI N	139+ 938
P2	N*1/2(2000) INTO LAMBDA K	1115+ 497
P3	N*1/2(2000) INTO GAM P,HELICITY=3/2	0+ 938
P4	N*1/2(2000) INTO GAM P,HELICITY=1/2	0+ 938
P5	N*1/2(2000) INTO GAM N,HELICITY=3/2	0+ 939
P6	N*1/2(2000) INTO GAM N,HELICITY=1/2	0+ 939
P7	N*1/2(2000) INTO K SIGMA	493+1189
P8	N*1/2(2000) INTO ETA N	939+ 548

06 N*1/2(2000) BRANCHING RATIOS

R1		N*1/2(2000) INTO (PI N)/TOTAL					(P1)	
R1	7	(0.25)		ALMEHED	72	IPWA		2/72
R1		(.08)		AYED	76	IPWA		11/77
R1		.04	.02	HOEHLER	79	IPWA	PI N TO PI N	12/79*
R2		N*1/2(2000) FROM GAMMA PROTON TO K LAMBDA					SQRT((P3+P4)*P2)	9/73
R2		(.0022)		DEANS	72	MPWA	GAM P-K LM,SOL D	9/73
R3		N*1/2(2000) FROM PI N TO K SIGMA					SQRT(P1*P7)	9/73
R3	1	(.05)		LANGBEIN	73	IPWA	PI N-K SIG,SOL 2	9/73
R3	2	(.022)		DEANS	75	DPWA	PI N TO K SIGMA	11/75
R3	2	VALUE GIVEN IS FROM SOLUTION 1, NOT PRESENT IN SOLUTIONS 2,3,4.						11/75
R4		N*1/2(2000) FROM PI N TO K LAMBDA					SQRT(P1*P2)	12/79*
R4		NOT SEEN		SAXON	80	DPWA	O PI- P TO K LAM	12/79*
R5		N*1/2(2000) FROM PI N TO ETA N					SQRT(P1*P8)	12/79*
R5		(+.03)		BAKER	79	DPWA	O PI- P TO ETA N	12/79*

REFERENCES FOR N*1/2(2000)

ALMEHED	72	NP B40 157	+LOVELACE	(RUTG)IJP
DEANS	72	PRD 6 1906	DEANS,JACOBS, LYONS,MONTGOMERY	(SOUTH FLA.)IJP
LANGBEIN	73	NP B53 251	LANGBEIN,WAGNER	(MUNICH)IJP
DEANS	75	NP B96 90	+MITCHELL,MONTGOMERY,+	(SFLA,ALABAMA)IJP
AYED	76	CEA-N-1921	AYED (THESIS)	(SACL)IJP
BAKER	79	NP B156 93	+BROWN,CLARK,DAVIES,DEPAGTER,EVANS+	(RHEL)IJP
HOEHLER	79	HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1 +KAISER,KOCH,PIETARINEN		/KARLSRUHE IJP
SAXON	80	NP B162 522	+BAKER,BELL,BLISSETT,BLOODWORTH+	(RHEL+BRIS)IJP

PAPERS NOT REFERRED TO IN DATA CARDS

MA	76	PRD 13 3027	E. MA,G. L. SHAW	(OREG+UCI)IJP

N(2040)

16 N*1/2(2040, JP=3/2-) I=1/2 D'''_{13}

THERE ARE INDICATIONS OF 1 OR 2 RESONANCES IN THIS WAVE WITH MASSES BETWEEN 1800 AND 2200 MEV. THE EVIDENCE IN THE PI N CHANNEL IS RATHER STRONG (SEE CUTKOSKY 79 AND HOEHLER 79) BUT IS NOT YET CONCLUSIVE ENOUGH FOR INCLUSION IN THE TABLES.

16 N*1/2(2040) MASS (MEV)

M	3	(2057.0)		DONNACH1	68	RVUE	PHASE-SHIFT ANAL	6/68
M	3	(2030.)		DONNACH2	68	RVUE	PHAS.SHIFT-CERN1	10/69
M	3	(2040.)		KIRSOPP	68	RVUE	PHASE SHIFT ANAL	10/69
M	3	WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1						10/69
M	X	(2030.0)	APPROX	LEA	69	CNTR	PI-P ELASTIC	8/69
M	X	SEE ALSO APLIN 71						
M	7	(2075.)		ALMEHED	72	IPWA		2/72
M	1	(2090.)		HICKS	73	MPWA	GAM P-ETA P	9/73
M	1	ONLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS.						9/73
M	1	M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII.						9/73
M		(2029.)		AYED	76	IPWA		11/77
M	L	1830.	50.	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*
M	H	2100.	80.	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*
M	LH	CUTKOSKY79 FINDS A LOWER MASS D13 RESONANCE, AS WELL AS ONE IN THIS						12/79*
M	LH	MASS REGION. BOTH ARE LISTED HERE, AND LABLED L AND H FOR LOW AND						12/79*
M	LH	HIGH, AWAITING CONFIRMATION OF THE LOWER MASS STATE.						12/79*
M		2081.	20.	HOEHLER	79	IPWA	PI N TO PI N	12/79*
M	4	(1900.)		SAXON	80	DPWA	O PI- P TO K LAM	12/79*
M		. . . .						
M		AVERAGE MEANINGLESS (SCALE FACTOR = 3.3)						

16 N*1/2(2040) WIDTH (MEV)

W		(293.0)		DONNACH1	68	RVUE		8/69
W	3	(290.)		DONNACH2	68	RVUE	PHAS.SHIFT-CERN1	10/69
W	3	(240.)		KIRSOPP	68	RVUE	PHASE SHIFT ANAL	10/69
W	7	(150.)		ALMEHED	72	IPWA		2/72
W	1	(224.)		HICKS	73	MPWA	GAM P-ETA P	9/73
W		(116.)		AYED	76	IPWA		11/77
W	L	125.	50.	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*
W	H	300.	100.	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*
W		265.	40.	HOEHLER	79	IPWA	PI N TO PI N	12/79*
W	4	(240.)		SAXON	80	DPWA	O PI- P TO K LAM	12/79*
W		. . . .						
W		AVERAGE MEANINGLESS (SCALE FACTOR = 1.7) SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.						

16 N*1/2(2040) REAL PART OF POLE POSITION (MEV)

REE	L	(1818.)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*
REE	H	(2053.)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*

16 N*1/2(2040) -2*IMAG PART OF POLE POSITION (MEV)

IME	L	(122.)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*
IME	H	(308.)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*

16 N*1/2(2040) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	L	(3.)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*
RER	H	(24.)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*

16 N*1/2(2040) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	L	(-3.)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*
IMR	H	(-10.)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*

16 N*1/2(2040) PARTIAL DECAY MODES

		DECAY MASSES
P1	N*1/2(2040) INTO PI N	139+ 938
P2	N*1/2(2040) INTO N PI PI	938+ 139+ 139
P3	N*1/2(2040) INTO N ETA	939+ 548
P4	N*1/2(2040) INTO LAMBDA K	1115+ 497
P5	N*1/2(2040) INTO GAM P,HELICITY=3/2	0+ 938
P6	N*1/2(2040) INTO GAM P,HELICITY=1/2	0+ 938
P7	N*1/2(2040) INTO GAM N,HELICITY=3/2	0+ 939
P8	N*1/2(2040) INTO GAM N,HELICITY=1/2	0+ 939
P9	N*1/2(2040) INTO SIGMA K	493+1189

16 N*1/2(2040) BRANCHING RATIOS

R1		N*1/2(2040) INTO (PI N)/TOTAL					(P1)	
R1	3	(.26)		DONNACH2	68	RVUE	PHAS.SHIFT-CERN1	10/69
R1	3	(.15)		KIRSOPP	68	RVUE	PHASE SHIFT ANAL	10/69
R1	7	(0.3)		ALMEHED	72	IPWA		2/72
R1		(.10)		AYED	76	IPWA		11/77
R1	L	.06	.03	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*
R1	H	.13	.05	CUTKOSKY	79	IPWA	PI N TO PI N	12/79*
R1		.06	.02	HOEHLER	79	IPWA	PI N TO PI N	12/79*
R1		. . . .						
R1		AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)						
R2		N*1/2(2040) INTO (N ETA)/TOTAL					(P3)	
R2	B	(0.) OR 0.009		CARRERAS	70	MPWA	T POLE + RESON.	5/70
R2	B	PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING						
R3		N*1/2(2040) FROM GAMMA PROTON TO K LAMBDA					SQRT((P5+P6)*P4)	9/73
R3		(.0070)		DEANS	72	MPWA	GAM P-K LM,SOL D	9/73
R4		N*1/2(2040) FROM GAMMA PROTON TO ETA PROTON					SQRT((P5+P6)*P3)	9/73
R4	1	(.0037)		HICKS	73	MPWA	GAM P-ETA P	9/73
R5		N*1/2(2040) FROM PI N TO K SIGMA					SQRT(P1*P9)	11/75
R5	2	(.014)TO .037		DEANS	75	DPWA	PI N TO K SIGMA	11/75
R5	2	RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.						11/75
R5	2	DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77						1/78
R5	2	AROUND 1920 MEV.						1/78
R6		N*1/2(2040) FROM PI N TO K LAMBDA					SQRT(P1*P4)	12/79*
R6	4	(+.03)		SAXON	80	DPWA	O PI- P TO K LAM	12/79*
R6	4	COUPLING PHASE IS NEAR -90 DEGREES. THIS IS THE ONLY D13 RESONANCE						12/79*
R6	4	ABOVE THE N*1/2(1700,3/2-) REQUIRED IN THE SAXON80 ANALYSIS.						12/79*
R7		N*1/2(2040) FROM PI N TO ETA N					SQRT(P1*P3)	12/79*
R7		NOT SEEN		BAKER	79	DPWA	O PI- P TO ETA N	12/79*

16 N*1/2(2040) PHOTON DECAY AMPL(GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1	N*1/2(2040) INTO GAM P, HELICITY=1/2 (GEV**-1/2)						
A1	.026	.052	DEVENIS2	74	DPWA	PI N PHOTO-PROD	4/75
A2	N*1/2(2040) INTO GAM P, HELICITY=3/2 (GEV**-1/2)						
A2	.128	.057	DEVENIS2	74	DPWA	PI N PHOTO-PROD	4/75
A3	N*1/2(2040) INTO GAM N, HELICITY=1/2 (GEV**-1/2)						
A3	.053	.083	DEVENIS2	74	DPWA	PI N PHOTO-PROD	4/75
A4	N*1/2(2040) INTO GAM N, HELICITY=3/2 (GEV**-1/2)						
A4	.100	.141	DEVENIS2	74	DPWA	PI N PHOTO-PROD	4/75

Data Card Listings

For notation, see key at front of Listings.

Baryons

N(2040), N(2100), N(2190)

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                              REFERENCES FOR N*1/2(2040)

DONNACHI1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACHI2 68 VIENNA 139        DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
KIRSOPP   68 THESIS            R G KIRSOPP                           (EDIN)

LEA       69 PL 29B 584        LEA,OADES,WARD,COWAN,+  (RHEL,BRISTOL,DARE)

CARRERAS  70 NP 16B 35         B CARRERAS, A DONNACHIE           (DARE,MCHS)

ALMEHED   72 NP B40 157        +LOVELACE                       (LUND,RUTG)IJP
DEANS     72 PRD 6 1906        DEANS,JACOBS, LYONS,MONTGOMERY (SOUTH FLA.)IJP
HICKS     73 PRD 7 2614        +DEANS,JACOBS,LYONS+ (CARN+ORNL+SOUTH FLA.)IJP

DEVENIS2  74 PL 52B 227        DEVENISH,LYTH,RANKIN      (DESY,LANC,BONN)IJP
DEANS     75 NP B96 90         +MITCHELL,MONTGOMERY,+      (SFLA,ALABAMA)IJP
AYED      76 CEA-N-1921        AYED (THESIS)                       (SACL)IJP

BAKER     79 NP B156 93        +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY  79 PRD 20 2839       +FORSYTH,HENDRICK,KELLY         (CARN+LBL)IJP
HOEHLER   79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN       /KARLSRUHE IJP
SAXON     80 NP B162 522       +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS

DONNACHI  69 NP 10B 433        A DONNACHIE, R KIRSOPP            (GLAS+EDIN)
AYED      70 PL 31B 598        +BAREYRE,VILLET                       (SACLAY)
APLIN     71 NP  B32 253       +COWAN,GIBSON,GILMORE++       (RHEL,BRISTOL)
MA        76 PRD 13 3027       E. MA,G. L. SHAW                (OREG+UCI)IJP
WINNIK    77 NP B128 66        +TOAFF,REVEL,GOLDBERG,BERNY            (HAIF)I
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N(2100) → 04 N*1/2(2100, JP=1/2-) I=1/2 S'''_{11}

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                      04  N*1/2(2100) MASS (MEV)

M          (2070.)                       ROYCHOUD  71 DPWA                   3/72
M    7     (2100.)                       ALMEHED   72 IPWA                   2/72
M          (2280.)                       AYED      76 IPWA                  11/77
M           1880.      20.               HOEHLER   79 IPWA   PI N TO PI N   12/79*
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                      04  N*1/2(2100) WIDTH (MEV)

W    7     (200.)                        ALMEHED   72 IPWA                   2/72
W          (320.)                        AYED      76 IPWA                  11/77
W            95.       30.               HOEHLER   79 IPWA   PI N TO PI N   12/79*
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                      04  N*1/2(2100) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      N*1/2(2100) INTO PI N                           139+ 938
P2      N*1/2(2100) INTO LAMBDA K                      1115+ 497
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                      04  N*1/2(2100) BRANCHING RATIOS

R1      N*1/2(2100) INTO (PI N)/TOTAL                          (P1)
R1   7        (0.5)                      ALMEHED   72 IPWA                   2/72
R1            (.15)                      AYED      76 IPWA                  11/77
R1             .09      .05              HOEHLER   79 IPWA   PI N TO PI N   12/79*

R2      N*1/2(2100) FROM PI N TO K LAMBDA                  SQRT(P1*P2)      12/79*
R2          NOT SEEN                     SAXON     80 DPWA  0 PI- P TO K LAM  12/79*
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                              REFERENCES FOR N*1/2(2100)

ROYCHOUD  71 NP B27 125        R K ROYCHOUDHURY,B H BRANSDEN        (DURH)IJP
ALMEHED   72 NP B40 157        +LOVELACE                       (LUND,RUTG)IJP
AYED      76 CEA-N-1921        AYED (THESIS)                       (SACL)IJP

HOEHLER   79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN       /KARLSRUHE IJP
SAXON     80 NP B162 522       +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS

MA        76 PRD 13 3027       E. MA,G. L. SHAW                (OREG+UCI)IJP
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N(2100) → 05 N*1/2(2100, JP=5/2-) I=1/2 D''_{15}

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                      05  N*1/2(2100) MASS (MEV)

M    7     (2100.)                       ALMEHED   72 IPWA                    2/72
M          (2076.)                       AYED      76 IPWA                   11/77
M    E     (1870.)                       BAKER     77 DPWA  0 PI- P TO K LAM.  1/78
M    E   IN ADDITION TO THE LISTED PARAMETERS OBTAINED IN A DPWA, BAKER 77     1/78
M    E   SEE A POSSIBLE EFFECT ABOVE 2000 MEV IN AN IPWA.                      1/78
M           2228.      30.               HOEHLER   79 IPWA   PI N TO PI N    12/79*
M          (1920.)                       SAXON     80 DPWA  0 PI- P TO K LAM 12/79*
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                      05  N*1/2(2100) WIDTH (MEV)

W    7     (150.)                        ALMEHED   72 IPWA                    2/72
W          (206.)                        AYED      76 IPWA                   11/77
W    E      (53.)                        BAKER     77 DPWA  0 PI- P TO K LAM.  1/78
W           310.       50.               HOEHLER   79 IPWA   PI N TO PI N    12/79*
W          (220.)                        SAXON     80 DPWA  0 PI- P TO K LAM 12/79*
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                      05  N*1/2(2100) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      N*1/2(2100) INTO PI N                           139+ 938
P2      N*1/2(2100) INTO LAMBDA K                      1115+ 497
P3      N*1/2(2100) INTO ETA N                          939+ 548
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                      05  N*1/2(2100) BRANCHING RATIOS

R1      N*1/2(2100) INTO (PI N)/TOTAL                          (P1)
R1   7        (0.2)                      ALMEHED   72 IPWA                    2/72
R1            (.09)                      AYED      76 IPWA                   11/77
R1             .07      .02              HOEHLER   79 IPWA   PI N TO PI N    12/79*

R2      N*1/2(2100) FROM PI N TO LAMBDA K                  SQRT(P1*P2)
R2   E        (-.06)                     BAKER     77 DPWA  0 PI- P TO K LAM.  1/78
R2            (-.05)                     SAXON     80 DPWA  0 PI- P TO K LAM 12/79*

R3      N*1/2(2100) FROM PI N TO ETA N                     SQRT(P1*P3)      12/79*
R3            (.066)                     BAKER     79 DPWA  0 PI- P TO ETA N 12/79*
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                              REFERENCES FOR N*1/2(2100)

ALMEHED   72 NP B40 157        +LOVELACE                       (LUND,RUTG)IJP
AYED      76 CEA-N-1921        AYED (THESIS)                       (SACL)IJP
BAKER     77 NP B126 365       +BLISSET,BLOODWORTH,BROOME,HART+    (RHEL)IJP

BAKER     79 NP B156 93        +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
HOEHLER   79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN       /KARLSRUHE IJP
SAXON     80 NP B162 522       +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS

MA        76 PRD 13 3027       E. MA,G. L. SHAW                (OREG+UCI)IJP
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2100 MEV REGION - PRODUCTION EXPERIMENTS

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                  114  N*1/2(2100, JP=    ) I=1/2     PRODUCTION EXPERIMENTS

                  RESONANCE-LIKE BUMP OBSERVED IN PP TO P(N PI+) AT CERN
                  ISR (DE KERRET 76). THE ENHANCEMENT SHOWS UP MORE
                  CLEARLY WHEN EVENTS CORRESPONDING TO TRANSVERSAL DECAYS
                  OF THE (N PI+) SYSTEM ARE SELECTED, CONTRARY TO WHAT
                  WOULD BE EXPECTED FOR A DIFFRACTIVE-LIKE EFFECT.

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                  114  N*1/2(2100) MASS (MEV) (PROD. EXPERIMENTS)

M          (2100.)                 DE KERRET 76 ISR  +  P(N PI+)E*=45GEV  1/78
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                  114  N*1/2(2100) PARTIAL DECAY MODES (PROD. EXP.)

                                                         DECAY MASSES
P1      N*1/2(2100) INTO PI N                            139+ 493
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                      REFERENCES FOR N*1/2(2100) PROD. EXPERIMENTS

DEKERRET 76 PL 63B 477,483     +NAGY,REGLER,BRANDT+    (CERN+HAMB+IPN+VIEN)
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N(2190) 71 N*1/2(2190, JP=7/2-) I=1/2 G_{17}

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                  THIS RESONANCE IS WELL ESTABLISHED.

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                  71  N*1/2(2190) MASS (MEV)

M          (2190.0)                      DIDDENS   63 CNTR   PI+- P TOTAL
M          (2210.0)                      HOHLER    64 RVUE   DATA + DISP REL
M          (2190.0)        APPROX        YOKOSAWA  66 CNTR   PI- P DSIG + POL  7/66
M    3     (2265.0)                      DONNACHI1 68 RVUE   PHASE-SHIFT ANAL  6/68
M          (2000.0)        APPROX        LEA       69 CNTR   PI-P ELASTIC      8/69
M           2180.      25.               ANDERSON  70 MMS  - PI- P TO PI- MMS  2/71
M    6     (2158.0)                      AYED      70 IPWA                     1/71
M    6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M          (2260.0)                      HULL      70 MPWA   SMALL ANGLE PI-P  1/71
M          (2160.0)   (50.0)             AMALDI    71 CNTR   P P AT 24 GEV    10/71
M          (2160.)                       BRANSDEN  71 DPWA                     3/72
M          (2200.)                       ROYCHOUD  71 DPWA                     3/72
M    7     (2225.)                       ALMEHED   72 IPWA                     2/72
M          (2190.)                       OTT       72 MPWA  0 PI-P BKWD ELSTC  2/73
M     1    (2208.)                       HICKS     73 MPWA   GAM P-ETA P       9/73
M     1  ONLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS.       9/73
M     1  M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII.      9/73
M          (2208.)    (20.)              ABE       74      + P+P->P+X,JCBN PK  4/75
M          (2141.)                       AYED      76 IPWA                    11/77
M          (2117.)                       BARBOUR   78 DPWA   PI-N PHOTO-PROD   3/79*
M           2140.      40.               HENDRY    78 MPWA   PI N TO PI N     12/79*
M          (2140.)                       BAKER     79 DPWA  0 PI- P TO ETA N  12/79*
M           2150.     100.               CUTKOSKY  79 IPWA   PI N TO PI N     12/79*
M           2140.      12.               HOEHLER   79 IPWA   PI N TO PI N     12/79*
M          (2180.)                       SAXON     80 DPWA  0 PI- P TO K LAM  12/79*
M             . . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
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Baryons
N(2190), N(2200)

Data Card Listings
For notation, see key at front of Listings.

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                  71   N*1/2(2190) WIDTH (MEV)

W            (200.0)                       DIDDENS    63 CNTR
W            (200.0)                       HOHLER     64 RVUE                         7/66
W            (220.0)         APPROX        YOKOSAWA   66 CNTR                         7/66
W     3      (298.0)                       DONNACH1   68 RVUE                         6/68
W             275.       70.               ANDERSON   70 MMS   -  PI- P TO PI- MMS   2/71
W     6      (325.0)                       AYED       70 IPWA                         1/71
W            (239.0)                       HULL       70 MPWA    SMALL ANGLE PI-P    1/71
W     7      (150.)                        ALMEHED    72 IPWA                         2/72
W      1     (193.)                        HICKS      73 MPWA    GAM P-ETA P          9/73
W            (243.)                        AYED       76 IPWA                        11/77
W            (220.)                        BARBOUR    78 DPWA    PI-N PHOTO-PROD     3/79*
W             270.       50.               HENDRY     78 MPWA    PI N TO PI N       12/79*
W            (319.)                        BAKER      79 DPWA  0 PI- P TO ETA N     12/79*
W             300.      100.               CUTKOSKY   79 IPWA    PI N TO PI N       12/79*
W             390.       30.               HOEHLER    79 IPWA    PI N TO PI N       12/79*
W             (80.)                        SAXON      80 DPWA  0 PI- P TO K LAM     12/79*
W             . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)
         SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                  71   N*1/2(2190) REAL PART OF POLE POSITION  (MEV)

REE         (2111.)                        CUTKOSKY   79 IPWA    PI N TO PI N       12/79*

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                  71   N*1/2(2190) -2*IMAG PART OF POLE POSITION  (MEV)

IME          (308.)                        CUTKOSKY   79 IPWA    PI N TO PI N       12/79*

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                  71   N*1/2(2190) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER           (24.)                        CUTKOSKY   79 IPWA    PI N TO PI N       12/79*

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                  71   N*1/2(2190) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR          (-12.)                        CUTKOSKY   79 IPWA    PI N TO PI N       12/79*

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                  71   N*1/2(2190) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N*1/2(2190) INTO PI N                           139+ 938
P2      N*1/2(2190) INTO LAMBDA K                      1115+ 493
P3      N*1/2(2190) INTO N PI PI                        938+ 139+ 139
P4      N*1/2(2190) INTO GAM P,HELICITY=3/2               0+ 938
P5      N*1/2(2190) INTO GAM P,HELICITY=1/2               0+ 938
P6      N*1/2(2190) INTO GAM N,HELICITY=3/2               0+ 939
P7      N*1/2(2190) INTO GAM N,HELICITY=1/2               0+ 939
P8      N*1/2(2190) INTO ETA N                          548+ 939
P9      N*1/2(2190) INTO SIGMA K                        493+1189

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                  71   N*1/2(2190) BRANCHING RATIOS

R1      N*1/2(2190) INTO (PI N)/TOTAL                         (P1)
R1            (0.3)        APPROX        DIDDENS    63 CNTR                         7/66
R1            (0.3)        APPROX        YOKOSAWA   66 CNTR                         7/66
R1    3       (0.349)                    DONNACH1   68 RVUE                         6/68
R1    6       (0.150)                    AYED       70 IPWA                         1/71
R1            (0.09)                     HULL       70 MPWA    SMALL ANGLE PI-P    1/71
R1    7       (0.35)                     ALMEHED    72 IPWA                         2/72
R1            (.25)                      OTT        72 MPWA  O PI-P BKWD ELSTC     2/73
R1            (.16)                      AYED       76 IPWA                        11/77
R1             .16        .04            HENDRY     78 MPWA    PI N TO PI N       12/79*
R1             .16        .07            CUTKOSKY   79 IPWA    PI N TO PI N       12/79*
R1             .14        .02            HOEHLER    79 IPWA    PI N TO PI N       12/79*
R1            . . . . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R2      N*1/2(2190) FROM GAMMA PROTON TO K LAMBDA           SQRT((P4+P5)*P2)      9/73
R2            (.0161)                    DEANS      72 MPWA    GAM P-K LM,SOL D    9/73

R3      N*1/2(2190) FROM GAMMA PROTON TO ETA PROTON         SQRT((P4+P5)*P8)      9/73
R3            (.0094)                    HICKS      73 MPWA    GAM P-ETA P          9/73

R4      N*1/2(2190) FROM PI N TO K SIGMA                    SQRT(P1*P9)          11/75
R4    4       (.014)TO    .019           DEANS      75 DPWA    PI N TO K SIGMA    11/75
R4    4   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                                11/75
R4    4   DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77               1/78
R4    4   AROUND 1920 MEV.                                                         1/78

R5      N*1/2(2190) FROM PI N TO K LAMBDA                   SQRT(P1*P2)          12/79*
R5            (-.02)                     SAXON      80 DPWA  O PI- P TO K LAM     12/79*

R6      N*1/2(2190) FROM PI N TO ETA N                      SQRT(P1*P8)          12/79*
R6            (+.052)                    BAKER      79 DPWA  O PI- P TO ETA N     12/79*

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                  71   N*1/2(2190) PHOTON DECAY AMPL(GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*1/2(2190) INTO GAM P, HELICITY=1/2  (GEV**-1/2)
A1            (-.030)                    BARBOUR    78 DPWA    PI-N PHOTO-PROD     3/79*

A2      N*1/2(2190) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2            (+.180)                    BARBOUR    78 DPWA    PI-N PHOTO-PROD     3/79*

A3      N*1/2(2190) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3            (-.085)                    BARBOUR    78 DPWA    PI-N PHOTO-PROD     3/79*

A4      N*1/2(2190) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4            (+.007)                    BARBOUR    78 DPWA    PI-N PHOTO-PROD     3/79*

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REFERENCES FOR N*1/2(2190)


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DIDDENS  63 PRL 10 262          +JENKINS, KYCIA, RILEY                (BNL) I
HOHLER   64 PL 12 149           G HOHLER, J GIESECKE           (KARLSRUHE) I
YOKOSAWA 66 PRL 16 714          +SUWA,HILL,ESTERLING, BOOTH      (ANL,CHIC) JP

DONNACH1 68 PL 26B 161          A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
  ALSO   68 VIENNA 139          DONNACHIE  RAPPORTEUR.S TALK           (GLAS)
  ALSO   68 THESIS              R G KIRSOPP                            (EDIN)

LEA      69 PL 29B 584          LEA,OADES,WARD,COWAN,+  (RHEL,BRISTOL,DARE)

ANDERSON 70 PRL 25,699          +BLESER,BLIEDEN,COLLINS++        (BNL,CARN)
AYED     70 KIEV CONF           R AYED,P BAREYRE, G VILLET          (SACL)IJP
HULL     70 PR D2 1783          J HULL, R LEACOCK                       (ISU)

AMALDI   71 PL  34B 435         +BIANCASTELLI,BOSIO,+  (I SANITA ROMA+CERN)
BRANSDEN 71 NP B26 511          ,OGDEN                              (DURH)IJP
  ALSO   70 NP B16 461          ROYCHOUDHURY,PERRIN,BRANSDEN        (DURH)IJP
ROYCHOUD 71 NP B27 125          R K ROYCHOUDHURY,B H BRANSDEN       (DURH)IJP

ALMEHED  72 NP B40 157          +LOVELACE                      (LUND,RUTG)IJP
DEANS    72 PRD 6 1906          DEANS,JACOBS, LYONS,MONTGOMERY (SOUTH FLA.)IJP
OTT      72 PL 42B 133          +TRISCHUK,VAVRA,RICHARDS,+ (MCGI,STLO,IOWA)IJP
  ALSO   72 MCGILL THESIS      J.VAVRA                               (MCGI) JP
HICKS    73 PRD 7 2614          +DEANS,JACOBS,LYONS+ (CARN+ORNL+SOUTH FLA.)IJP

ABE      74 PL 53B 114          +ALSPECTOR,BOMBEROWITZ+      (RUTG,UPNJ,FSU)
DEANS    75 NP B96 90           +MITCHELL,MONTGOMERY,+       (SFLA,ALABAMA)IJP
AYED     76 CEA-N-1921          AYED (THESIS)                       (SACL)IJP

BARBOUR  78 NP B141 253         BARBOUR,CRAWFORD,PARSONS               (GLAS)
HENDRY   78 PRL 41 222          ARCHIBALD W. HENDRY              (IND+LBL)IJP
BAKER    79 NP B156 93          +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PRD 20 2839         +FORSYTH,HENDRICK,KELLY          (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN          /KARLSRUHE IJP
SAXON    80 NP B162 522         +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS

BARGER   66 PRL 16 913          V BARGER, D CLINE                     (WISC) P
CARROLL  66 PRL 16 288          +CORBETT,DAMERELL,MIDDLEMAS, +   (RHEL,OXF)J-L
CARROLL  66 PRL 17 1274         +CORBETT,DAMERELL,MIDDLEMAS, +   (RHEL,CXF)J-L
    ERRATUM CHANGING THE RATHER WEAK DETERMINATION OF J-L TO +1         (2.)
KORMANYO 66 PRL 16 709          KORMANYOS,KRISCH,OFALLON, +       (MICH,ANL) P
BUSZA    67 NC 52A 331          +DAVIS,DUFF,HEYMANN, +      (LOUC,WESTFIELD)
AYED     70 PL 31B 598          +BAREYRE,VILLET                       (SACLAY)
MA       76 PRD 13 3027         E. MA,G. L. SHAW                 (OREG+UCI)IJP
WINNIK   77 NP B128 66          +TOAFF,REVEL,GOLDBERG,BERNY           (HAIFI)I
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N(2200) 113 N*1/2(2200, JP=9/2-) I=1/2 **G'_{19}**

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                  113  N*1/2(2200) MASS (MEV)

M            (2133.)                       AYED       76 IPWA                         1/78
M             2200.     100.               HENDRY     78 MPWA    PI N TO PI N       12/79*
M            (2200.)                       CUTKOSKY   79 IPWA    PI N TO PI N       12/79*
M             2268.      15.               HOEHLER    79 IPWA    PI N TO PI N       12/79*
M             . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                  113  N*1/2(2200) WIDTH (MEV)

W             (193.)                       AYED       76 IPWA                         1/78
W              350.     100.               HENDRY     78 MPWA    PI N TO PI N       12/79*
W             (330.)                       CUTKOSKY   79 IPWA    PI N TO PI N       12/79*
W              300.      40.               HOEHLER    79 IPWA    PI N TO PI N       12/79*
W             . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                  113  N*1/2(2200) REAL PART OF POLE POSITION  (MEV)

REE         (2169.)                        CUTKOSKY   79 IPWA    PI N TO PI N       12/79*

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                  113  N*1/2(2200) -2*IMAG PART OF POLE POSITION  (MEV)

IME          (290.)                        CUTKOSKY   79 IPWA    PI N TO PI N       12/79*

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                  113  N*1/2(2200) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER           (15.)                        CUTKOSKY   79 IPWA    PI N TO PI N       12/79*

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                  113  N*1/2(2200) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR           (-7.)                        CUTKOSKY   79 IPWA    PI N TO PI N       12/79*

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                  113  N*1/2(2200) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N*1/2(2200) INTO PI N                           139+ 938
P2      N*1/2(2200) INTO LAMBDA K                      1115+ 497
P3      N*1/2(2200) INTO ETA N                          939+ 548

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                  113  N*1/2(2200) BRANCHING RATIOS

R1      N*1/2(2200) INTO (PI N)/TOTAL                         (P1)
R1            (.09)                      AYED       76 IPWA                         1/78
R1             .09        .02            HENDRY     78 MPWA    PI N TO PI N       12/79*
R1            (.10)                      CUTKOSKY   79 IPWA    PI N TO PI N       12/79*
R1             .10        .02            HOEHLER    79 IPWA    PI N TO PI N       12/79*
R1            . . . . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R2      N*1/2(2200) FROM PI N TO K LAMBDA                   SQRT(P1*P2)          12/79*
R2         NOT SEEN                      SAXON      80 DPWA  O PI- P TO K LAM     12/79*

R3      N*1/2(2200) FROM PI N TO ETA N                      SQRT(P1*P3)          12/79*
R3            (-.043)                    BAKER      79 DPWA  O PI- P TO ETA N     12/79*

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Data Card Listings

For notation, see key at front of Listings.

Baryons

N(2200), N(2220), N(>2500), N(2600)


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                         REFERENCES FOR N*1/2(2200)

AYED      76  CEA-N-1921        AYED (THESIS)                          (SACL)IJP
HENDRY    78  PRL 41 222        ARCHIBALD W. HENDRY                 (IND+LBL)IJP

BAKER     79  NP B156 93        +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+   (RHEL)IJP
CUTKOSKY  79  PRD 20 2839       +FORSYTH,HENDRICK,KELLY            (CARN+LBL)IJP
HOEHLER   79  HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN            /KARLSRUHE IJP
SAXON     80  NP B162 522       +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
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N(2220) — H_{19}

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90  N*1/2(2220, JP=9/2+) I=1/2
THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

                 90  N*1/2(2220) MASS (MEV)

M       (2200.)   APPROX.          BUSZA     67 OSPK   LEG.POLYN.ANAL.    2/71
M  6    (2221.0)                   AYED      70 IPWA                      1/71
M  6  FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M       (2245.0)                   HULL      70 MPWA   SMALL ANGLE PI-P   1/71
M       (2249.)                    AYED      76 IPWA                     11/77
M        2300.      100.           HENDRY    78 MPWA   PI N TO PI N      12/79*
M       (2050.)                    BAKER     79 DPWA  O PI- P TO ETA N   12/79*
M       (2250.)                    CUTKOSKY  79 IPWA   PI N TO PI N      12/79*
M        2205.       10.           HOEHLER   79 IPWA   PI N TO PI N      12/79*
M         . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

                 90  N*1/2(2220) WIDTH (MEV)

W  6    (258.0)                    AYED      70 IPWA                      1/71
W       (329.0)                    HULL      70 MPWA   SMALL ANGLE PI-P   1/71
W       (347.)                     AYED      76 IPWA                     11/77
W        450.       150.           HENDRY    78 MPWA   PI N TO PI N      12/79*
W       (450.)                     CUTKOSKY  79 IPWA   PI N TO PI N      12/79*
W        365.        30.           HOEHLER   79 IPWA   PI N TO PI N      12/79*
W         . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

                 90  N*1/2(2220) REAL PART OF POLE POSITION  (MEV)

REE     (2180.)                    CUTKOSKY  79 IPWA   PI N TO PI N      12/79*

                 90  N*1/2(2220) -2*IMAG PART OF POLE POSITION  (MEV)

IME     (400.)                     CUTKOSKY  79 IPWA   PI N TO PI N      12/79*

                 90  N*1/2(2220) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER     (37.)                      CUTKOSKY  79 IPWA   PI N TO PI N      12/79*

                 90  N*1/2(2220) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR     (-21.)                     CUTKOSKY  79 IPWA   PI N TO PI N      12/79*

                 90  N*1/2(2220) PARTIAL DECAY MODES

                                                     DECAY MASSES
P1     N*1/2(2220) INTO PI N                          139+ 938
P2     N*1/2(2220) INTO N ETA                         939+ 548
P3     N*1/2(2220) INTO LAMBDA K                     1115+ 497

                 90  N*1/2(2220) BRANCHING RATIOS

R1     N*1/2(2220) INTO (PI N)/TOTAL                (P1)
R1  6      (0.140)                 AYED      70 IPWA                      1/71
R1         (0.15)                  HULL      70 MPWA   SMALL ANGLE PI-P   1/71
R1         (.20)                   AYED      76 IPWA                     11/77
R1          .12       .04          HENDRY    78 MPWA   PI N TO PI N      12/79*
R1         (.20)                   CUTKOSKY  79 IPWA   PI N TO PI N      12/79*
R1          .18       .015         HOEHLER   79 IPWA   PI N TO PI N      12/79*
R1        . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

R2     N*1/2(2220) FROM PI N TO K LAMBDA           SQRT(P1*P3)           12/79*
R2        NOT SEEN                 SAXON     80 DPWA  O PI- P TO K LAM.  12/79*

R3     N*1/2(2200) FROM PI N TO ETA N              SQRT(P1*P2)           12/79*
R3         (.034)                  BAKER     79 DPWA  O PI- P TO ETA N   12/79*
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                         REFERENCES FOR N*1/2(2220)

BUSZA     67  NC 52A 331        +DAVIS,DUFF,HEYMANN,NIMMON +      (LOUC+LOWC)
AYED      70  KIEV CONF         R AYED,P BAREYRE, G VILLET           (SACL)IJP
HULL      70  PR D2 1783        J HULL, R LEACOCK                        (ISU)

AYED      76  CEA-N-1921        AYED (THESIS)                        (SACL)IJP
HENDRY    78  PRL 41 222        ARCHIBALD W. HENDRY               (IND+LBL)IJP

BAKER     79  NP B156 93        +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY  79  PRD 20 2839       +FORSYTH,HENDRICK,KELLY          (CARN+LBL)IJP
HOEHLER   79  HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN          /KARLSRUHE IJP
SAXON     80  NP B162 522       +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

                         PAPERS NOT REFERRED TO IN DATA CARDS

AYED      70  PL 31B 598        +BAREYRE,VILLET                       (SACLAY)
MA        76  PRD 13 3027       E. MA,G. L. SHAW                 (OREG+UCI)IJP
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2200 MEV REGION – PRODUCTION EXPERIMENTS

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     111  N*1/2(2200, JP=?) I=1/2          PRODUCTION EXPERIMENTS
     WE LIST HERE BUMPS OBSERVED IN THE RANGE 1900-2500 MEV.

               111  N*1/2(2200) MASS (MEV)  (PROD. EXP.)

M          2160.      50.          AMALDI    71 SAS  +  P P TO P MM          1/78
M          2120.      30.          APPLE     77 SPEC +  P P TO P (P PIO)     1/78
M          2362.      20.          APPLE     77 SPEC +  P P TO P (N PI+)     1/78
M  D    45 1930.      20.          SUGAHARA  79 HBC  +0 PI-P AT 4.5 GEV     12/79*
M  D    34 2120.      10.          SUGAHARA  79 HBC  +0 PI-P AT 4.5 GEV     12/79*
M  D   SEEN IN N*3/2(1232) PI PI (NOT RHO)
M  R   176(2200.)                  SUGAHARA  79 HBC  +  PI-P AT 4.5 GEV     12/79*
M  R   N*3/2(1232) RHO IS DOMINANT.  IDENTIFIED WITH G17(2190).
M        . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 7.7)

               111  N*1/2(2200) WIDTH (MEV)  (PROD. EXP.)

W           125.      70.          APPLE     77 SPEC +  P P TO P (P PIO)     1/78
W            75.      50.          APPLE     77 SPEC +  P P TO P (N PI+)     1/78
W  D    45  160.      30.          SUGAHARA  79 HBC  +0 PI-P AT 4.5 GEV     12/79*
W  D    34   20.      30.          SUGAHARA  79 HBC  +0 PI-P AT 4.5 GEV     12/79*
W        . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED ABOVE.
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                         REFERENCES FOR N*1/2(2200)

AMALDI    71  PL 34B 435        +BIANCASTELLI,BOSIO,MATTHIAE+    (SANI+CERN)
APPLE     77  LNC 18 167        +ASH,CHENG,COYNE,GROSSMAN+      (PRIN+PAVIA)
SUGAHARA  79  NC 52A 373        +SUZUKI,FUKAWA,KABE,KICHIMI,OCHIAI+    (KEK)
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>2500 MEV REGION – FORMATION EXPERIMENTS

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     128  N*1/2(>2500) I=1/2

     WE LIST HERE I=1/2 RESONANCES WITH MASS GREATER THAN
     ABOUT 2.5 GEV WHICH HAVE BEEN SEEN IN A SINGLE PARTIAL
     WAVE ANALYSIS ONLY.  ALL RESONANCES WHICH HAVE BEEN
     OBSERVED IN >1 ANALYSIS AT ABOUT THE SAME MASS ARE
     GIVEN A SEPARATE LISTING WITH THE APPROPRIATE QUANTUM
     NUMBERS.

               128  N*1/2(>2500) MASS  (MEV)

M        3500.     200.            HENDRY    78 MPWA    PI N  L115     12/79*
M        3800.     200.            HENDRY    78 MPWA    PI N  M117     12/79*
M        4100.     200.            HENDRY    78 MPWA    PI N  N119     12/79*
M        . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

               128  N*1/2(>2500) WIDTH  (MEV)

W        1300.     200.            HENDRY    78 MPWA    PI N  L115     12/79*
W        1600.     200.            HENDRY    78 MPWA    PI N  M117     12/79*
W        1900.     300.            HENDRY    78 MPWA    PI N  N119     12/79*
W        . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

               128  N*1/2(>2500) PARTIAL DECAY MODES

                                                     DECAY MASSES
P1     N*1/2(>2500) INTO PI N                         139+ 938

               128  N*1/2(>2500) BRANCHING RATIOS

R1     N*1/2(>2500) INTO (PI N)/TOTAL                (P1)            12/79*
R1          .055      .02          HENDRY    78 MPWA    PI N  L115     12/79*
R1          .040      .015         HENDRY    78 MPWA    PI N  M117     12/79*
R1          .030      .015         HENDRY    78 MPWA    PI N  N119     12/79*
R1        . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
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                         REFERENCES FOR N*1/2(>2500)

HENDRY    78  PRL 41 222        ARCHIBALD W. HENDRY               (IND+LBL)IJP
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N(2600) — I_{111}

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120  N*1/2(2600, JP=11/2-) I=1/2

               120  N*1/2(2600) MASS  (MEV)

M        2700.     100.            HENDRY    78 MPWA    PI N TO PI N   12/79*
M        2577.      50.            HOEHLER   79 IPWA    PI N TO PI N   12/79*
M        . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)
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Baryons

Data Card Listings

N(2600), N(2650), N(2700), N(2800), N(3030)

For notation, see key at front of Listings.

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                 120  N*1/2(2600) WIDTH  (MEV)

W        900.     100.               HENDRY     78 MPWA    PI N TO PI N      12/79*
W        400.     100.               HOEHLER    79 IPWA    PI N TO PI N      12/79*
W           . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 3.5)

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                 120  N*1/2(2600) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      N*1/2(2600) INTO PI N                              139+ 938

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                 120  N*1/2(2600) BRANCHING RATIOS

R1      N*1/2(2600) INTO (PI N)/TOTAL                      (P1)              12/79*
R1            .08       .02          HENDRY     78 MPWA    PI N TO PI N      12/79*
R1            .05       .01          HOEHLER    79 IPWA    PI N TO PI N      12/79*
R1          . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

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                       REFERENCES FOR N*1/2(2600)

HENDRY   78 PRL 41 222          ARCHIBALD W. HENDRY                 (IND+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN           /KARLSRUHE IJP

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2650 MEV REGION – MISCELLANEOUS EXPERIMENTS

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                 72  N*1/2(2650,          ) I=1/2  PRODUCTION EXPERIMENTS

                 ROYCHOUDHURY 71 CLAIM F15(2400) AND G19(2400) TO BE
                 POSSIBLE RESONANCES. BRANSDEN 71 FIND THE POSSIBLE
                 RESONANT CANDIDATES S11(2520) AND H19(2590).  RECENT
                 PI N PWA'S ESTABLISH THE EXISTENCE OF A JP=11/2- STATE
                 IN THIS REGION, BUT THE POSSIBILITY THAT THERE
                 ARE ALSO OTHER STATES REMAINS. SEE THE MINI-REVIEW
                 PRECEDING THE N AND DELTA LISTINGS.

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                 72  N*1/2(2650) MASS (MEV) (PROD. EXP.)

M       (2700.0)                     ALVAREZ   64 CNTR    PI PHOTOPROD
M       (2660.0)                     HOHLER    64 RVUE    DATA + DISP REL
M       (2600.0)       APPROX        WAHLIG    64 OSPK  0 PI-P CH EX
M       (2633.0)                     BARGER    66 FIT     TOTAL + CH EX    11/67
M        2649.0     10.0             CITRON    66 CNTR    PI+- P TOTAL      7/66

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                 72  N*1/2(2650) WIDTH (MEV) (PROD. EXP.)

W        (100.0)                     ALVAREZ   64 CNTR
W        (200.0)                     HOHLER    64 RVUE                      7/66
W        (425.0)                     BARGER    66 FIT     TOTAL + CH EX    11/67
W         360.0     20.0             CITRCN    66 CNTR                      7/66

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                 72  N*1/2(2650) PARTIAL DECAY MODES (PROD. EXP.)

                                                             DECAY MASSES
P1      N*1/2(2650) INTO PI N                              139+ 938
P2      N*1/2(2650) INTO LAMBDA K                         1115+ 497
P3      N*1/2(2650) INTO N PI PI                           938+ 139+ 139

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                 72  N*1/2(2650) BRANCHING RATICS (PROD. EXP.)

R1      N*1/2(2650) INTO (PI N)/TOTAL                      (P1)
R1     ONLY (J+1/2)*( PI N/TOTAL) MEASURED FOR THIS STATE
R1  B        (0.456)  (0.018)        BARGER     66 RVUE    TOTAL + CH EXC.  11/67
R1            0.436    0.028         CITRCN     66 CNTR    TOTAL CROSS-SEC. 11/67
R1  B        (0.30)                  BARGER     67 RVUE    USES KORMANYOS67 11/67
R1  B  USES REGGE AMP.+RESCN. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE
R1  B  FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
R1  D        (0.24)                  DIKMEN     67 RVUE    USES KORMANYOS66 11/67
R1  D  USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES
R1           (0.06)                  KORMANYOS 67 CNTR     PI-P AT 180 DEG. 11/67

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                       REFERENCES FOR N*1/2(2650) (PROD. EXP.)

ALVAREZ   64 PRL 12 710          +BAR-YAM,KERN,LUCKEY,OSBORNE, +    (MIT,CEA)
HOHLER    64 PL 12 149           G HOHLER, J GIESECKE             (KARLSRUHE) I
WAHLIG    64 PRL 13 103          +MANNELLI,SODICKSON,FACKLER,WARD, +    (MIT)
BARGER    66 PR 151 1123         V BARGER, M OLSSON                    (WISC)
CITRON    66 PR 144 1101         +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I
BARGER    67 PR 155 1792         V BARGER, D CLINE                     (WISC) P
DIKMEN    67 PRL 18 798          F N DIKMEN                            (MICH)
KORMANYO  67 PR 164 1661         KORMANYOS, KRISCH, OFALLON, +     (MICH,ANL) P

                                 PAPERS NOT REFERRED TO IN DATA CARDS

BAACKE    67 NC 51A 761          J BAACKE, M YVERT            (KARLSRUHE,ORSAY)J-L
DOLEN     68 PR 166 1768         R DOLEN, D HORN, C SCHMID              (CIT)
WAHLIG    68 PR 168 1515         M A WAHLIG, I MANNELLI            (MIT,PISA)
     FINAL VERSION OF DATA USED IN WAHLIG 64.  IN CONFUNCTION WITH
     CITRON 66 TOTAL CRCSS SECTICNS, THIS CHARGE EXCHANGE DATA GIVES
     COMPLEX ELASTIC SCATTERING AMPLITUDE AT 0 DEGREES.

BRANSDEN  71 NP B26 511          +OGDEN                              (DURH)IJP
    ALSO  70 NP B16 461          ROYCHOUDHURY,PERRIN,BRANSDEN        (DURH)IJP
ROYCHOUD  71 NP B27 125          R K ROYCHOUDHURY,B H BRANSDEN       (DURH)IJP

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N(2700) → K_{113}

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                 121  N*1/2(2700, JP=13/2+) I=1/2

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                 121  N*1/2(2700) MASS  (MEV)

M        3000.    100.               HENDRY     78 MPWA    PI N TO PI N      12/79*
M        2612.     45.               HOEHLER    79 IPWA    PI N TO PI N      12/79*
M           . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 3.5)

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                 121  N*1/2(2700) WIDTH  (MEV)

W         900.    150.               HENDRY     78 MPWA    PI N TO PI N      12/79*
W         350.     50.               HOEHLER    79 IPWA    PI N TO PI N      12/79*
W           . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 3.5)

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                 121  N*1/2(2700) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      N*1/2(2700) INTO PI N                              139+ 938

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                 121  N*1/2(2700) BRANCHING RATIOS

R1      N*1/2(2700) INTO (PI N)/TOTAL                      (P1)              12/79*
R1            .07       .02          HENDRY     78 MPWA    PI N TO PI N      12/79*
R1            .04       .01          HOEHLER    79 IPWA    PI N TO PI N      12/79*
R1          . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

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                       REFERENCES FOR N*1/2(2700)

HENDRY   78 PRL 41 222          ARCHIBALD W. HENDRY                 (IND+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN           /KARLSRUHE IJP

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N(2800) → G''_{19}

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                 122  N*1/2(2800, JP=9/2-) I=1/2

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                 122  N*1/2(2800) MASS  (MEV)

M        2792.    100.               HOEHLER    79 IPWA    PI N TO PI N      12/79*

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                 122  N*1/2(2800) WIDTH  (MEV)

W         240.    100.               HOEHLER    79 IPWA    PI N TO PI N      12/79*

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                 122  N*1/2(2800) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      N*1/2(2800) INTO PI N                              139+ 938

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                 122  N*1/2(2800) BRANCHING RATIOS

R1      N*1/2(2800) INTO (PI N)/TOTAL                      (P1)              12/79*
R1            .02       .015         HOEHLER    79 IPWA    PI N TO PI N      12/79*

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                       REFERENCES FOR N*1/2(2800)

HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN           /KARLSRUHE IJP

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N(3030) BUMPS

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                 73  N*1/2(3030, JP=       ) I=1/2  PRODUCTION EXPERIMENTS

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                 73  N*1/2(3030) MASS (MEV) (PROD. EXP.)

M       (3080.0)                     HOHLER    64 RVUE    DATA + DISP REL    7/66
M       (3030.0)                     CITRON    66 CNTR    PI+- P TOTAL       7/66

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                 73  N*1/2(3030) WIDTH (MEV) (PROD. EXP.)

W        (400.0)                     CITRON    66 CNTR                       7/66

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                 73  N*1/2(3030) PARTIAL DECAY MODES (PROD. EXP.)

                                                             DECAY MASSES
P1      N*1/2(3030) INTO PI N                              139+ 938
P2      N*1/2(3030) INTO N PI PI                           938+ 139+ 139

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Data Card Listings

For notation, see key at front of Listings.

Baryons

N?(3245), N(3690), N?(3755), Δ(1232)

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                    73  N*1/2(3030) BRANCHING RATIOS (PROD. EXP.)

R1     N*1/2(3030) INTO (PI N)/TOTAL                        (P1)
R1    ONLY (J+1/2)*( PI N/TOTAL) MEASURED FOR THIS STATE
R1  B       (0.088)  (0.016)          BARGER    66 RVUE    TOTAL + CH EXC.  11/67
R1          (0.048)                   CITRON    66 CNTR    TOTAL CROS.SEC.  11/67
R1  B       (0.12)                    BARGER    67 CNTR    USES KORMANYOS66 11/67
R1  B  USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE
R1  B  FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
R1  D       (0.016)                   DIKMEN    67 RVUE    USES KORMANYOS67 11/67
R1  D  USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES

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                         REFERENCES FOR N*1/2(3030) (PROD. EXP.)

HOHLER   64 PL 12 149         G HOHLER, J GIESECKE              (KARLSRUHE) I
BARGER   66 PR 151 1123       V BARGER, M OLSSON                     (WISC)
CITRON   66 PR 144 1101       +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I
BARGER   67 PR 155 1792       V BARGER, D CLINE                      (WISC) P
DIKMEN   67 PRL 18 798        F N DIKMEN                             (MICH)

                         PAPERS NOT REFERRED TO IN DATA CARDS

KORMANYO 67 PR 164 1661       KORMANYOS, KRISCH, OFALLON, +     (MICH,ANL) P
DOLEN    68 PR 166 1768       R DOLEN, D HORN, C SCHMID               (CIT)

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N?(3245) BUMPS

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74  N* /2(3245, JP=     )          PRODUCTION EXPERIMENTS

EXISTENCE NOT CONCLUSIVELY ESTABLISHED.  I-SPIN
NOT DETERMINED, BUT THE NARROW WIDTH PRECLUDES
IDENTIFICATION WITH THE N*3/2(3230).
OMITTED FROM TABLE.

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                    74  N* /2(3245) MASS (MEV) (PROD. EXP.)

M         3245.0     10.0             KORMANYOS 67 CNTR     PI-P 180 DEG EL    6/68

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                    74  N* /2(3245) WIDTH (MEV) (PROD. EXP.)

W         (35.0)   OR LESS            KORMANYOS 67 CNTR                        6/68

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                    74  N* /2(3245) PARTIAL DECAY MODES (PROD. EXP.)

                                                              DECAY MASSES
P1      N* /2(3245) INTO PI N                                 139+ 938

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                    74  N* /2(3245) BRANCHING RATIOS (PROD. EXP.)

R1      N* /2(3245) INTO (PI N)/TOTAL                       (P1)
R1     J IS NOT KNOWN.  FOLLOWING IS (J+1/2)*(PI N)/TOTAL
R1          (0.37)                    KORMANYOS 67 CNTR                        6/68

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                         REFERENCES FOR N* /2(3245) (PROD. EXP.)

KORMANYO 67 PR 164 1661       KORMANYOS, KRISCH, OFALLON, +     (MICH,ANL) P

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N(3690) BUMPS

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75  N*1/2(3690, JP=     ) I=1/2  PRODUCTION EXPERIMENTS

A BUMP SEEN IN THE INVARIANT MASS OF A VERY COMPLI-
CATED STATE (N + SEVEN PIS), SO AS EVIDENCE FOR
A NEW RESONANCE IT IS NOT CONCLUSIVE.  NOT INCLUDED
IN TABLE.

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                    75  N*1/2(3690) MASS (MEV) (PROD. EXP.)

M         3690.0     10.0             BARTKE    67 HBC  +  PI+P 8 PRONGS      8/67

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                    75  N*1/2(3690) WIDTH (MEV) (PROD. EXP.)

W           50.0     30.0             BARTKE    67 HBC  +                     8/67

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                    75  N*1/2(3690) PARTIAL DECAY MODES (PROD. EXP.)

                                                              DECAY MASSES
P1      N*1/2(3690) INTO N + 7 PIS

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                         REFERENCES FOR N*1/2(3690) (PROD. EXP.)

BARTKE   67 PL 24B 118        +CZYZEWSKI,DANYSZ,+           (CRACOW,ORSAY) I

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N?(3755) BUMPS

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76  N* /2(3755, JP=     )          PRODUCTION EXPERIMENTS

A SMALL PEAK IN THE (P P PBAR) INVARIANT MASS FROM
8.4 BEV/C PI+ P TO PI+ P P PBAR EVENTS.  AS EVIDENCE
FOR A NEW RESONANCE IT IS NOT CONCLUSIVE.  OMITTED
FROM TABLE.

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                    76  N* /2(3755) MASS (MEV) (PROD. EXP.)

M         3755.0      8.0             EHRLICH   68 HBC  +  PI+ P P PBAR       6/68

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                    76  N* /2(3755) WIDTH (MEV) (PROD. EXP.)

W           40.0     20.0             EHRLICH   68 HBC  +                     6/68

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                    76  N* /2(3755) PARTIAL DECAY MODES (PROD. EXP.)

                                                              DECAY MASSES
P1      N* /2(3755) INTO PI+ P P PBAR                         139+ 938+ 938+ 938

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                         REFERENCES FOR N* /2(3755) (PROD. EXP.)

EHRLICH  68 PRL 20 686        R EHRLICH,R J PLANO,J B WHITTAKER (RUTGERS)

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S=0 I=3/2 NUCLEON STATES (Δ)

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Δ(1232) P'_{33}

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33  N*3/2(1232, JP=3/2+) I=3/2

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.
SEE CARTER 71 AND CARTER 73 FOR PI N CROSS-SECTION
DATA IN THIS REGION.

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                    33  N*3/2(1232)  MASS (MEV)

M          (1234.)                    ROPER     65 DPWA ++0 PHASE SHIFT AN.
M          (1235.)                    ALMEHED   72 IPWA                     2/72
M    3     (1243.3)   (1241.7)        CHENG     73         FIT CARTER 71    2/74
M    3  THE TWO ENTRIES ARE FROM TWO DIFFERENT PARAMETRIZATIONS OF THE     2/74
M    3  RESONANCE CONTRIBUTUION TO THE P33 PHASE SHIFT.                    2/74
M          (1230.4)                   TSCHANG   73         FIT CARTER71 P33 1/74
M          (1231.)                    AYED      76 IPWA                    11/77
M           1233.      2.             HOEHLER   79 IPWA    PI N TO PI N    12/79*

M++         1236.0     0.55           OLSSON    65 RVUE ++ TOTAL-SIGMA DATA
M++  2      1231.0     1.5            CARTER    71 MPWA ++ PI+P SIG. TOTAL  1/74
M++  1      1231.1      .2            CARTER    73 IPWA ++ PI N 88-310 MEV  9/73
M++  1  EXPERIMENTAL QUANTITY-SEE CARTER73 FOR COULOMB BARRIER CORRECTIONS  9/73
M++  2  EXPERIMENTAL QUANTITY-SEE CARTER71 FOR COULOMB BARRIER CORRECTIONS  1/74
M++         . . . . . . . . . .
M++ AVERAGE MEANINGLESS (SCALE FACTOR = 8.4)

M+         (1231.8)                   BERENDS   75 IPWA +  GAM P TO PI NUC  4/75
M+          1230.6     1.8            CRAWFORD  75 DPWA    PI N PHOTO-PROD  1/76
M+         (1231.7)                   BARBOUR   76 DPWA    PI N PHOTO-PROD  1/76
M+   4     (1231.2)                   BARBOUR   78 DPWA    PI-N PHOTO-PROD  3/79*
M+   4  SUPERSEDES BARBOUR 76.                                              3/79*
M+          1234.9     1.4            MIROSHNIC 79      +  FIT PHOTO-PROD  12/79*
M+          . . . . . . . . . .
M+  AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

MO          1236.45    0.65           OLSSON    65 RVUE  0
MO          1232.9     0.6            CARTER    71 MPWA  0 PI-P SIG. TOTAL  1/71
MO          . . . . . . . . . .
MO  AVERAGE MEANINGLESS (SCALE FACTOR = 4.0)

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                    33  N*3/2(1232) WIDTH (MEV)

W           (120.)                    ROPER     65 DPWA ++0 PHASE SHIFT AN.
W           (129.)                    ALMEHED   72 IPWA                     2/72
W    3      (152.2)   (145.8)         CHENG     73         FIT CARTER 71    2/74
W           (120.)                    TSCHANG   73         FIT CARTER71 P33 1/74
W           (109.)                    AYED      76 IPWA                    11/77
W            116.      5.             HOEHLER   79 IPWA    PI N TO PI N    12/79*

W++          120.0     2.0            OLSSON    65 RVUE ++
W++  2       111.1     1.8            CARTER    71 MPWA ++ PI+P SIG. TOTAL  1/74
W++  1       111.5      .4            CARTER    73 IPWA ++ PI N 88-310 MEV  9/73
W++         . . . . . . . . . .
W++ AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

W+           120.2     3.9            CRAWFORD  75 DPWA    PI N PHOTO-PROD  1/76
W+          (117.4)                   BARBOUR   76 DPWA    PI N PHOTO-PROD  1/76
W+   4      (111.0)                   BARBOUR   78 DPWA    PI-N PHOTO-PROD  3/79*
W+           131.1     2.4            MIROSHNIC 79      +  FIT PHOTO-PROD  12/79*
W+          . . . . . . . . . .
W+  AVERAGE MEANINGLESS (SCALE FACTOR = 2.4)

WO           119.6     2.4            OLSSON    65 RVUE  0
WO           114.7     3.0            CARTER    71 MPWA  0 PI-P SIG TOT.    1/71
WO          . . . . . . . . . .
WO  AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

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                    33  (N*0) - (N*++) MASS DIFFERENCE (MEV)

D    R       (0.45)   (0.85)          OLSSON    65 RVUE
D     2       1.3      1.9            CARTER    71 MPWA ++ PI+-P SIG. TOTAL 1/74
D     1       1.4       .4            CARTER    73 IPWA    PI N 88-310 MEV  9/73
D    R     REDUNDANT WITH DATA IN MASS LISTING.
D           . . . . . . . . . .
D   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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Baryons

Δ(1232)

Data Card Listings

For notation, see key at front of Listings.

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             33  (N*0)-(N*++) WIDTH DIFFERENCE (MEV)                      9/73

WD   2        6.5       2.2             CARTER    71 MPWA ++ PI+-P SIG. TOTAL  1/74
WD   1       10.3       1.3             CARTER    73 IPWA    PI N 88-310 MEV   9/73
WD             . . . . . . . . .
WD  AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

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             33  N*3/2(1232) REAL PART OF POLE POSITION (MEV)

REE  M     (1214.)                      MICHAEL   67                          2/74
REE        (1211.)                      BALL      72                          2/73
REE  P      1211.6       0.7            PDG       72          FIT DELTA 33    2/73
REE 3      (1210.7)    (1210.7)         CHENG     73          FIT CARTER 71   2/74
REE         1214.5      10.             NOGOVA    73          FIT ALMEHED72   2/74
REE        (1213.)                      SPEARMAN  74          FIT ZERO TRJCTRY 4/75
REE  M  FIT INCLUDES OLSSON 65 PARAMETERS PLUS SCATTERING LENGTH PLUS 6
REE  M  PHASE SHIFT VALUES FOR TPI=120 TO 492 MEV.
REE  P  ERROR EST. FROM FITS WITH SOMEWHAT VARYING ASSUMPTIONS
REE            . . . . . . . . .
REE AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R++  U      1211.5        .6            BALL      75       ++ FIT CARTER 73   11/75
R++  U      1210.9        .8            LICHTENB  75       ++ FIT CARTER 73   11/75
R++  C      1209.6        .5            VASAN     76       ++ FIT CARTER 73    1/76
R++  C  FROM FITS TO COULOMB-BARRIER-CORRECTED CARTER 73 PHASE SHIFT.          3/79*
R++  U     (1210.5)TO(1210.8)           VASAN     76       ++ FIT CARTER 73    1/76
R++  U  FROM FITS TO CARTER 73 NUCLEAR PHASE SHIFT WITHOUT COULOMB BARRIER     3/79*
R++  U  CORRECTIONS.                                                           3/79*
R++  Z      1210.4        .17           ZIDELL    78       ++ FIT ZIDELL 78    3/79*
R++  Z  FIT TO ZIDELL 78 NUCLEAR PHASE SHIFT WITHOUT COULOMB                   3/79*
R++  Z  BARRIER CORRECTIONS.                                                   3/79*
R++            . . . . . . . . .
R++ AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

RE+         1208.        2.             CAMPBELL  76       +  FIT PHOTO-PROD   2/77
RE+         1206.9+-0.9 TO 1210.5+-1.8 MIROSHNIC 79       +  FIT PHOTO-PROD  12/79*

REO  U     (1211.6)                     BALL      75        0 FIT CARTER 73   11/75
REO  U      1210.9       1.4            LICHTENB  75        0 FIT CARTER 73   11/75
REO  C      1210.75       .6            VASAN     76        0 FIT CARTER 73    1/76
REO  U     (1210.2)                     VASAN     76        0 FIT CARTER 73    1/76
REO  Z      1209.5        .41           ZIDELL    78        0 FIT ZIDELL 78    3/79*
REO            . . . . . . . . .
REO AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

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             33  N*3/2(1232) -IMAG PART OF POLE POSITION (MEV)

IME  M      (52.)                       MICHAEL   67                          2/74
IME         (50.)                       BALL      72                          2/73
IME  P       49.5        1.8            PDG       72          FIT DELTA 33    2/73
IME 3       (50.7)      (50.6)          CHENG     73          FIT CARTER 71   2/74
IME          48.6        5.             NOGOVA    73          FIT ALMEHED72   2/74
IME         (49.)                       SPEARMAN  74          FIT ZERO TRJCTRY 4/75
IME            . . . . . . . . .
IME AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

I++  U       50.1         .6            BALL      75       ++ FIT CARTER 73   11/75
I++  U       49.6         .75           LICHTENB  75       ++ FIT CARTER 73   11/75
I++  C       50.4         .5            VASAN     76       ++ FIT CARTER 73    1/76
I++  U      (49.9)TO (50.0)             VASAN     76       ++ FIT CARTER 73    1/76
I++  Z       49.745       .14           ZIDELL    78       ++ FIT ZIDELL 78    3/79*
I++            . . . . . . . . .
I++ AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

IM+          53.         2.             CAMPBELL  76       +  FIT PHOTO-PROD   2/77
IM+          55.6+-1.0 TO 58.3+-1.1    MIROSHNIC 79       +  FIT PHOTO-PROD  12/79*

IMO  U      (53.0)                      BALL      75        0 FIT CARTER 73   11/75
IMO  U       53.25       1.75           LICHTENB  75        0 FIT CARTER 73   11/75
IMO  C       52.8         .6            VASAN     76        0 FIT CARTER 73    1/76
IMO  U      (52.9)TO (53.1)             VASAN     76        0 FIT CARTER 73    1/76
IMO  Z       52.45        .2            ZIDELL    78        0 FIT ZIDELL 78    3/79*
IMO            . . . . . . . . .
IMO AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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             33  N*3/2(1232) ABSOLUTE VALUE OF ELASTIC
                             POLE RESIDUE (MEV)

ABS         (53.)                       BALL      73          FIT DELTA 33    9/73

A++  C      (52.4)TO (53.2)             VASAN     76       ++ FIT CARTER 73    1/76
A++  U      (52.1)TO (52.4)             VASAN     76       ++ FIT CARTER 73    1/76

ABO  C      (54.8)TO (55.0)             VASAN     76       ++ FIT CARTER 73    1/76
ABO  U      (55.2)TO (55.3)             VASAN     76       ++ FIT CARTER 73    1/76

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             33  N*3/2(1232) PHASE OF ELASTIC POLE RESIDUE (RADIANS)

PH          (-.81)                      BALL      73          FIT DELTA 33    9/73

P++  C      (-.822)TO -.833             VASAN     76       ++ FIT CARTER 73    1/76
P++  U      (-.823)TO -.830             VASAN     76       ++ FIT CARTER 73    1/76

PHO  C      (-.840)TO -.847             VASAN     76       ++ FIT CARTER 73    1/76
PHO  U      (-.848)TO -.856             VASAN     76       ++ FIT CARTER 73    1/76

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             33  N*3/2(1232) PHASE OF M1+(3/2) PHOTOPRODUCTION
                             MULTIPOLE AMPLITUDE POLE RESIDUE

M1P      INFORMATION ON THE PHASE (AND MAGNITUDE) OF THE M1+(3/2) MULTIPOLE   12/79*
M1P      AMPLITUDE POLE RESIDUE IS CONTAINED IMPLICITLY IN THE PAPER OF       12/79*
M1P      MIROSHNICHENKO 79.  THEY FIND THAT THE PHASE IS CONSISTENT WITH      12/79*
M1P      BEING EQUAL TO THAT OF THE ELASTIC POLE RESIUDE.                     12/79*

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             33  N*3/2(1232) MAGNETIC MOMENT  (NUCLEAR MAGNETONS)

MM          (+4.7)TO (+6.7)             NEFKENS   78          PI P TO PI P GAM 12/79*

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             33  N*3/2(1232) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N*3/2(1232) INTO N PI                             938+ 139
P2      N*3/2(1232) INTO N GAMMA                          938+   0
P3      N*3/2(1232) INTO N PI PI                          938+ 139+ 139
P4      N*3/2(1232) INTO GAM NUCLEON, HELICITY=1/2          0+ 938
P5      N*3/2(1232) INTO GAM NUCLEON, HELICITY=3/2          0+ 938

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             33  N*3/2(1232) BRANCHING RATIOS

R1      N*3/2(1232) INTO (N GAMMA)/(N PI) (PERCENT)         (P2)/(P1)
R1          0.55        0.02            DALITZ    66 RVUE                     7/68
R1          0.53        0.025           BERENDS   71 IPWA    PHOTOPROD. ANAL. 10/71
R1             . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R2      N*3/2(1232)O INTO (N PI)/TOTAL                      (P1)
R2   2         (.99)                    CARTER    71 MPWA ++ PI+-P SIG. TOTAL  1/74
R2             (1.)                     AYED      76 IPWA                     11/77
R2             (1.)                     HOEHLER   79 IPWA    PI N TO PI N     12/79*

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             33  N*3/2(1232) PHOTON DECAY AMPL(GEV**-1/2)

     FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
   REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*3/2(1232) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)
A1          -.144       .014            DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A1          -.142       .006            MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A1          -.138       .004            KNIES     74 DPWA    PI N PHOTO PROD   2/74
A1          -.140       .006            METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A1          -.142       .001            MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A1          -.130       .002            CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A1         (-.139)                      KRIVETS   75 DPWA    PI-N PHOTO-PROD   1/78
A1         (-.129)                      BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A1          -.141       .004            FELLER    76 DPWA    PI N PHOTO-PROD   2/77
A1          -.136       .002            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79*
A1          -.139       .002            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79*
A1   4      -.142       .007            BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A1   N     (-.140)                      NOELLE    78         PI-N PHOTO-PROD   1/80*
A1   N  CONVERTED TO OUR CONVENTIONS USING M=1.232, W=.110 FROM NOELLE 78.    1/80*
A1             . . . . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 2.1)

A2      N*3/2(1232) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)
A2          -.262       .015            DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A2          -.259       .016            MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A2          -.253       .002            KNIES     74 DPWA    PI N PHOTO PROD   2/74
A2          -.254       .007            METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A2          -.261       .001            MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A2          -.248       .002            CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A2         (-.253)                      KRIVETS   75 DPWA    PI-N PHOTO-PROD   1/78
A2         (-.251)                      BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A2          -.256       .003            FELLER    76 DPWA    PI N PHOTO-PROD   2/77
A2          -.255       .002            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79*
A2          -.256       .002            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79*
A2   4      -.271       .010            BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A2   N     (-.247)                      NOELLE    78         PI-N PHOTO-PROD   1/80*
A2   N  CONVERTED TO OUR CONVENTIONS USING M=1.232, W=.110 FROM NOELLE 78.    1/80*
A2             . . . . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 2.9)

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                         REFERENCES FOR N*3/2(1232)
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OLSSON    65 PRL 14 118          M G OLSSON                          (WISC)
ROPER     65 PR 138 B190         L D ROPER, R M WRIGHT, B T FELD  (LRL+MIT)IJP

DALITZ    66 PR 146 1180         DALITZ,SUTHERLAND                  (OXFORD)
    CONTAINS REFERENCES TO EARLIER WORK ON DELTA PHOTOPRODUCTION.

MICHAEL   67 PR 156 1677         MICHAEL                            (RHEL)IJP
BERENDS   71 NP  B30 575         +WEAVER                       (CEA,MIT,TUFT)
CARTER    71 NP B26 445          +WILLIAMS, BUGG, BUSSEY, DANCE  (CAVE,RHEL)

ALMEHED   72 NP B40 157          +LOVELACE                     (LUND,RUTG)IJP
BALL      72 PRL 28 1143         +CAMPBELL,LEE,SHAW          (UTAH,BOIS,UCI)
PDG       72 PL 39B 103          SODING,BARTELS,+  (DESY+LBL+BRAN+CERN+HELS)IJP
BALL      73 PRD 7 2789          BALL,LEE,SHAW                   (UTAH+UCI)IJP
CARTER    73 NP B58 378          CARTER,BUGG,CARTER    (CAVENDISH+QUEEN MARY)IJP
CHENG     73 PRD 7 2249          CHENG,LICHTENBERG                   (IND)IJP
DEVENISH  73 PL 47B 53           DEVENISH,RANKIN,LYTH     (LOUC+BONN+LANC)IJP
MOORHOUS  73 PL 43B 44           MOORHOUSE, OBERLACK            (GLAS+LBL)IJP
NOGOVA    73 NP B61 445          NOGOVA,PISUT(IP SLOVAK ACAD SCI,COMENIUS U)IJP
    ALSO  73 NP B61 438          NOGOVA,PISUT+(IP SLOVK ACAD SCI,COMENIUS U)IJP
    ALSO  73 NP B65 544          NOGOVA,PISUT+(IP SLOVK ACAD SCI,COMENIUS U)IJP
TSCHANG   73 NP B59 445          TSCHANG,PARKINSON       (FLOR+GAINESVILLE)IJP

KNIES     74 PRD 9 2680          KNIES,MOORHOUSE,OBERLACK       (LBL,GLAS)IJP
METCALF   74 NP B76 253          W J METCALF,R L WALKER             (CIT)IJP
MOORHOUS  74 PRD 9 1             MOORHOUSE,OBERLACK,ROSENFELD   (GLAS+LBL)IJP
SPEARMAN  74 PRD 10 1660         T D SPEARMAN     (TRINITY COLLEGE,DUBLIN)

BALL      75 PRD 11 1171         J S BALL,R L GOBLE                 (UTAH)IJP
BERENDS   75 NP B84 342          BERENDS,DONNACHIE               (LEID,MCHS)
CRAWFORD  75 NP B97 125          R L CRAWFORD                       (GLAS)IJP
KRIVETS   75 SJNP 20 430         +MIROSHNICHENKO,NIKIFOROV,SANIN+   (KIEV)IJP
    ALSO  74 SJNP 19 112         KRIVETS,NIKIFOROV,SANIN,SHALATSKII (KIEV)IJP
LICHTENB  75 LNC 12 616          D B LICHTENBERG                     (IND)IJP

AYED      76 CEA-N-1921          AYED (THESIS)                      (SACL)IJP
BARBOUR   76 NP B111 358         I. M. BARBOUR,R. L. CRAWFORD       (GLAS)IJP
CAMPBELL  76 PRD 14 2431         CAMPBELL,SHAW,BALL        (BOIS+UCI+UTAH)IJP
FELLER    76 NP B104 219         +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP
VASAN     76 NP B106 535         S. S. VASAN                        (CARN)IJP
    ALSO  76 NP B106 526         S. S. VASAN                        (CARN)IJP

AZNAURYA  77  EFI-264(57)-77     +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
BARBOUR   78 NP B141 253         BARBOUR,CRAWFORD,PARSONS           (GLAS)
NEFKENS   78 PRD 18 3911         +ARMAN,BALLAGH,GLODIS,HADDOCK+  (UCLA+CATH)IJP
NOELLE    78 PTP 60 778          P. NOELLE                          (NAGO)
ZIDELL    78 LNC 21 140          ZIDELL,ARNDT,ROPER                  (VPI)IJP

HOEHLER   79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                 +KAISER,KOCH,PIETARINEN         /KARLSRUHE IJP
MIROSHNI  79 SJNP 29 94          MIROSHNICHENKO,NIKIFOROV,SANIN+  (KHARKOV)IJP
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Data Card Listings

For notation, see key at front of Listings.

Baryons

Δ(1232), Δ(1550), Δ(1650)

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                          PAPERS NOT REFERRED TO IN DATA CARDS

DONNACHI 68 PL 26B 161    DONNACHIE,LOVELACE,KIRSOPP                  (CERN)
FONDA    73 PRD 8 353     FONDA,GHIRARDI,SHAW      (ICTP-TRIESTE+TRST)IJP
HENYEY   74 PR D9 302     HENYEY,KANE                             (MICH)IJP
OLSSON   74 LNC 10 333    OLSSON                                  (CERN)IJP
PFEIL    74 NP B73 166    PFEIL,ROLLNIK,STANKOWSKI                    (BCNN)
SUZUKI   74 NP B68 413    SUZUKI,KUROKAWA,KONDO                      (TOKYO)

GANENKO  75 SJNP 22 522   +KRIVETS,MIROSHNICHENKO,NIKIFOROV+     (KIEV)IJP
NIGRO    75 NP B84 201    NIGRO,SPILLANTINI,VALENTE           (PADO,FRAS)
GANENKO1 76 SJNP 24 284   +KRIVETS,MIROSHNICHENKO,NIKIFOROV+     (KIEV)IJP
GANENKO2 76 SJNP 24 594   +GORBENKO,KRIVETS,KOLESNIKOV+          (KIEV)IJP
ZABEV    76 SJNP 24 70    ZABEV,KUZNETSOV,STUKOV                 (TMSK)IJP

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1232 MEV REGION – PRODUCTION EXPERIMENTS

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          81 N*3/2(1232, JP=3/2+) I=3/2    PRODUCTION EXPERIMENTS

          SEE THE MINI-REVIEW PRECEDING THE N AND DELTA LISTINGS
          FOR A DISCUSSION OF PRODUCTION EXPERIMENTS.

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          81  N*3/2(1232) MASS (MEV) (PROD. EXP.)

M           1217.      8.            ANDERSON 70 MMS  -  PI- P TO PI- MMS  2/71
M           1227.0     7.0           ELLIS    71 CNTR    MMS PP 3.7 GEV/C 10/71
M        . . . . . . . . .
M    AVG    1222.7     5.3    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    STUDENT1222.7     5.9    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M++        (1232.0)   (6.0)          FERRO-LUZ 65 HBC ++ K+P TO KO P PI+
M++        (1236.0)                  DEANS    66 RVUE ++ PI+P TOTAL        7/66
M++        (1233.4)   (4.4)          GIDAL    66 DBC  ++ D D TO NN(NN) PI  7/66
M++        (1224.0)   (2.0)          HABER    70 DBC     K-D TO 4 BOD(P)   7/70
M++         1236.0     2.0           COLTON   72 HBC  ++ PP TO PI+PN 7GEV  1/73
M++         1226.0     2.0           COLTON   72 HBC  ++  TO PI+PI-PP      1/73
M++         1222.0     3.0           COLTON   72 HBC  ++ TO PI+PI-PIOPP    1/73
M++         1226.0     2.0           COLTON   72 HBC  ++ TO PI+PI-PI-PN    1/73
M++        (1231.)    (3.)           LEWIS    73 HBC  ++ K+ P TO K P 2PI   1/76
M++         1219.      5.            LICHTMAN 74 HBC  ++ PI+P TO 3PI P     4/75
M++         1213.      3.            LICHTMAN 74 HBC  ++ PI-P TO 3PI P     4/75
M++        (1224.)     5. TO 10.     BRAUN2   75  BC     PBAR P AND D,5.7 11/75
M++         1224. TO 1228.           ATHERTON 76 HBC     PBAR P 5.7 GEV    2/77
M++     2K  1226.      3.            GOGGI2   78 ISR  ++ PP TO DELTA P PI  1/80*
M++   840  1225.      2.            APELDOORN 79 HBC ++ PBAR P 7.2 GEV/C 12/79*
M++      . . . . . . . . .
M++ AVG     1226.1     2.2    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.6)
M++ STUDENT1225.3      1.1    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M+          1224. TO 1230.           BRAUN1   75 HBC     PBAR P 5.7 GEV   11/75
M+   1      1256.     15.            APPLE    77 SPEC +  P P TO P (N PI+)  1/78
M+   1  NOT SEEN IN P P TO P (P PIO).                                      1/78

MO          1231.     11.            COOPER   74 HBC   O D P CEX           4/75
MO         (1230.)                   BRAUN1   75 HBC     PBAR P 5.7 GEV   11/75
MO         (1220.)     5. TO 10.     BRAUN2   75  BC     PBAR P AND D,5.7 11/75

M-         (1241.3)   (5.1)          GIDAL    66 DBC  -                    7/66
M-          1239.0     5.0           COLTON   72 HBC  -  TO PI+PI-PI-PN    1/73

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          81  (N*-) - (N*++) MASS DIFFERENCE (MEV) (PROD. EXP.)

D             7.9      6.8           GIDAL    66 DBC

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          81  N*3/2(1232) WIDTH (MEV) (PROD. EXP.)

W           115.       5.            ANDERSON 70 MMS  -  PI- P TO PI- MMS  2/71
W           105.0      7.0           ELLIS    71 CNTR    MMS PP 3.7 GEV/C 10/71
W           141.      11.            MUSGRAVE 75 HBC     K+ P TO K PI N   11/75
W        . . . . . . . . .
W    AVG    115.2      7.5    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
W    STUDENT 114.5     4.6    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W++        (125.0)   (30.0)          FERRO-LUZ 65 HBC ++
W++        (121.0)                   DEANS    66 RVUE ++                   7/66
W++        (124.0)   (14.0)          GIDAL    66 DBC  ++                   7/66
W++        (120.0)    (8.0)          HABER    70 DBC     K-D TO 4 BOD(P)   7/70
W++         115.0      6.0           COLTON   72 HBC  ++ PP TO PI+PN 7GEV  1/73
W++         127.0      5.0           COLTON   72 HBC  ++  TO PI+PI-PP      1/73
W++         122.0      9.0           COLTON   72 HBC  ++ TO PI+PI-PIOPP    1/73
W++         106.0      7.0           COLTON   72 HBC  ++ TO PI+PI-PI-PN    1/73
W++        (146.)    (10.)           LEWIS    73 HBC  ++ K+ P TO K P 2PI   1/76
W++         166.      14.            LICHTMAN 74 HBC  ++ PI+P TO 3PI P     4/75
W++         134.       7.            LICHTMAN 74 HBC  ++ PI-P TO 3PI P     4/75
W++        (110.)     10. TO 20.     BRAUN2   75  BC     PBAR P AND D,5.7 11/75
W++          96. TO  113.            ATHERTON 76 HBC     PBAR P 5.7 GEV    2/77
W++     2K  113.      16.            GOGGI2   78 ISR  ++ PP TO DELTA P PI  1/80*
W++   840   100.       5.           APELDOORN 79 HBC ++ PBAR P 7.2 GEV/C 12/79*
W++      . . . . . . . . .
W++ AVG     117.5      5.5    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
W++ STUDENT 118.5      3.8    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W+          110. TO  130.            BRAUN1   75 HBC     PBAR P 5.7 GEV   11/75
W+   1       20.      60.      20.   APPLE    77 SPEC +  P P TO P (N PI+)  1/78

WO          109.      32.      25.   COOPER   74 HBC   O D P CEX           4/75
WO         (120.)                    BRAUN1   75 HBC     PBAR P 5.7 GEV   11/75
WO         (120.)     10. TO 20.     BRAUN2   75  BC     PBAR P AND D,5.7 11/75

W-         (149.0)   (18.0)          GIDAL    66 DBC  -                    7/66
W-          237.0     22.0           COLTON   72 HBC  -  TO PI+PI-PI-PN    1/73

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               REFERENCES FOR N*3/2(1232) (PROD. EXP.)

FERRO-LU 65 NC 36 1101    FERRO-LUZZI,GEORGE, +                      (CERN)
DEANS    66 PREPRINT      S R DEANS, W G HOLLADAY              (VANDERBILT)
GIDAL    66 PR 141 1261   G GIDAL, A KERNAN, S KIM                    (LRL)

ANDERSON 70 PRL 25 699    +BLESER,BLIEDEN,COLLINS++              (BNL,CARN)
HABER    70 NP 17B 289    +SHAPIRA,MERRILL,MCNARI++           (SABRE COLL)
ELLIS    71 PRL 27 442    +MAGLICH,NOREM,SANNES,SILVERMAN           (RUTG)
COLTON   72 PR D6 95      E COLTON, A KIRSCHBAUM                      (LBL)
LEWIS    73 NP B60 283    +ALLEN,JACOBS,DANYSZ,ISLAM+(LOWC+LOIC+CCEF)
COOPER   74 NP B79 259    COOPER,SEIDL,VANDERVELDE                   (MICH)
LICHTMAN 74 NP B81 31     LICHTMAN,BISWAS,CASON,KENNEY,MCGAHAN+(NDAM)I

BRAUN1   75 NP B95 481    +GERBER,MAURER,MICHALON,SCHIBY+ (STRB,LPNP)I
BRAUN2   75 NP B95 503    +GERBER,MAURER,MICHALON,SCHIBY+ (STRB,LPNP)I
MUSGRAVE 75 NP B87 365    +PEETERS,SCREINER,WHITMORE,YUTA           (ANL)

ATHERTON 76 NP B103 381   ATHERTON,FRENCH,SKURA,BOHM+      (CERN+PRAG)I
APPLE    77 LNC 18 167    +ASH,CHENG,COYNE,GROSSMAN+       (PRIN+PAVIA)
GOGGI2   78 NP B143 365   +CAVALLI-SFORZA,CONTA+           (CERN+PAVI)
APELDOOR 79 NP B156 111   VAN APELDOORN,HARTING,HOLTHUIZEN+      (AMST)

                 PAPERS NOT REFERRED TO IN DATA CARDS

ALEXANDE 73 NP B52 221    ALEXANDER,BENARY+(TEL-AVIV+HEIDELBERG+DESY)
BEAUPRE  73 NP B66 93         (AACH+BERL+BONN+CERN+NDAM+PENN+TCHO)I
BERLAND  74 NP B75 93     BERLAND,HABER,HODOUS,HULSIZER,+           (MIT)I
   ALSO  74 PL 51B 187    BERLAND,HABER,HODOUS,HULSIZER, +          (MIT)I
ATHERTON 75 NC 30A 505    ATHERTON,BAR-NIR,FRENCH,SKURA+  (CERN+PRAG)I
STRACHMA 75 NP B98 120    STRACHMAN, BRAUN, GERBER, MAURER+ (LPNP+STRB)I
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Δ(1550) — P'_{31}

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Δ(1550)  110  N*3/2(1550, JP=1/2+) I=3/2     P'31                     11/77
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          110  N*3/2(1550) MASS (MEV)                                 11/77

M    8    (1550.)                 LONGACRE  77 IPWA    PI N TO 2PI N   11/77
M    8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                  11/77
M         (1525.)                 BARNHAM   79 IPWA ++ PI N TO 2PI N   12/79*

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          110  N*3/2(1550) WIDTH (MEV)                                11/77

W    8      (110.)                LONGACRE  77 IPWA    PI N TO 2PI N   11/77
W            (40.)                BARNHAM   79 IPWA ++ PI N TO 2PI N   12/79*

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          110  N*3/2(1550) REAL PART OF POLE POSITION (MEV)           11/77

RE   8      1554. OR 1553.        LONGACRE  77 IPWA    PI N TO 2PI N   11/77

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          110  N*3/2(1550) -2*IMAG PART OF POLE POSITION (MEV)        11/77

IM   8       105. OR 104.         LONGACRE  77 IPWA    PI N TO 2PI N   11/77

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          110  N*3/2(1550) PARTIAL DECAY MODES                        11/77

                                                      DECAY MASSES
P1      N*3/2(1550) INTO PI N                         139+ 938
P2      N*3/2(1550) INTO N*3/2(1232) PI              1232+ 139
P3      N*3/2(1550) INTO N RHO,S=3/2                  938+ 776

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          110  N*3/2(1550) BRANCHING RATIOS                           11/77

R1      N*3/2(1550) FROM PI N TO N*3/2(1232) PI        SQRT(P1*P2)    11/77
R1   8        (+.11)              LONGACRE  77 IPWA    PI N TO 2PI N   11/77
R1             .13      .05       BARNHAM   79 IPWA ++ PI N TO 2PI N   12/79*

R2      N*3/2(1550) FROM PI N TO N RHO,S=3/2           SQRT(P1*P3)    11/77
R2   8        (+.08)              LONGACRE  77 IPWA    PI N TO 2PI N   11/77
R2             .17      .05       BARNHAM   79 IPWA ++ PI N TO 2PI N   12/79*

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                   REFERENCES FOR N*3/2(1550)

LONGACRE 77 NP B122 493   LONGACRE,DOLBEAU                      (SACL)IJP
   ALSO  76 NP B108 365   DOLBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP
BARNHAM  79  IC/HENP/78/3 +GLICKMAN,MIER-JEDRZEJOWICZ+          (LOIC)IJP
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Δ(1650) — S'_{31}

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Δ(1650)  82  N*3/2(1650, JP=1/2-) I=3/2     S'31
            THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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          82  N*3/2(1650) MASS (MEV)

M          (1648.0)   (12.0)      DEVLIN    65 CNTR   PI+- P TOTAL
M    1     (1695.0)               BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
M    1           WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    3     (1635.0)               DONNACHI  68 RVUE   PHASE-SHIFT ANAL  6/68
M    6     (1614.0)               AYED      70 IPWA                     1/71
M    6   ENER. DEP. FIT OF ARGAND DIAGRAM
M    4     (1617.0)               DAVIES    70 RVUE   P-S ANAL  SOL A   8/69
M    7     (1620.)                ALMEHED   72 IPWA                     2/72
M           1622. TO 1688.        CRAWFORD  75 DPWA   PI N PHOTO-PROD   1/76
M      L    1625. OR 1600.        LONGACRE  75 IPWA   PI N TO 2PI N    11/75
M      L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75. 11/75
M          (1623.)                AYED      76 IPWA                    11/77
M          (1680.)                BARBOUR   76 DPWA   PI N PHOTO-PROD   1/76
M    8     (1580.)                LONGACRE  77 IPWA   PI N TO 2PI N    11/77
M    8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                   11/77
M    2     (1662.)                BARBOUR   78 DPWA   PI-N PHOTO-PROD   3/79*
M    2   SUPERSEDES BARBOUR 76.                                         3/79*
M    5     (1620.)                BARNHAM   79 IPWA ++ PI N TO 2PI N   12/79*
M           1620.      20.        CUTKOSKY  79 IPWA   PI N TO PI N     12/79*
M           1610.       7.        HOEHLER   79 IPWA   PI N TO PI N     12/79*
M        . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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Baryons
Δ(1650), Δ(1670)

Data Card Listings
For notation, see key at front of Listings.

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                         82   N*3/2(1650) WIDTH (MEV)

W    1       (250.0)                       BAREYRE    68 RVUE                         11/67
W    3       (177.0)                       DONNACH1   68 RVUE                          6/68
W    6       (142.0)                       AYED       70 IPWA                          1/71
W    4       (141.0)                       DAVIES     70 RVUE     P-S ANAL   SOL A     8/69
W    7       (140.)                        ALMEHED    72 IPWA                          2/72
W              125. TO  214.               CRAWFORD   75 DPWA     PI N PHOTO-PROD      1/76
W     L        160. OR  150.               LONGACRE   75 IPWA     PI N TO 2PI N       11/75
W            (161.)                        AYED       76 IPWA                         11/77
W            (246.)                        BARBOUR    76 DPWA     PI N PHOTO-PROD      1/76
W    8       (120.)                        LONGACRE   77 IPWA     PI N TO 2PI N       11/77
W     2      (180.)                        BARBOUR    78 DPWA     PI-N PHOTO-PROD      3/79*
W     5      (120.)                        BARNHAM    79 IPWA ++  PI N TO 2PI N       12/79*
W              140.         20.            CUTKOSKY   79 IPWA     PI N TO PI N        12/79*
W              139.         18.            HOEHLER    79 IPWA     PI N TO PI N        12/79*
W         SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
W              . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                         82   N*3/2(1650) REAL PART OF POLE POSITION (MEV)        11/75

RE          (1583.)                        LONGACRE   75 IPWA     PI N TO 2PI N       11/75
RE   8        1575. OR 1572.               LONGACRE   77 IPWA     PI N TO 2PI N       11/77
RE          (1597.)                        CUTKOSKY   79 IPWA     PI N TO PI N        12/79*

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                         82   N*3/2(1650) -2*IMAG PART OF PCLE POSITION (MEV)     11/75

IM           (143.)                        LONGACRE   75 IPWA     PI N TO 2PI N       11/75
IM   8         119. OR 128.                LONGACRE   77 IPWA     PI N TO 2PI N       11/77
IM           (120.)                        CUTKOSKY   79 IPWA     PI N TO PI N        12/79*

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                         82   N*3/2(1650) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER           (-6.)                        CUTKOSKY   79 IPWA     PI N TO PI N        12/79*

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                         82   N*3/2(1650) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR          (-15.)                        CUTKOSKY   79 IPWA     PI N TO PI N        12/79*

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                         82   N*3/2(1650) PARTIAL DECAY MODES

                                                                   DECAY MASSES
P1       N*3/2(1650) INTO PI N                                   139+ 938
P2       N*3/2(1650) INTO N PI PI                                938+ 139+ 139
P3       N*3/2(1650) INTO GAM NUCLEON, HELICITY=1/2                0+ 938
P4       N*3/2(1650) INTO N*3/2(1232) PI                        1232+ 139
P5       N*3/2(1650) INTC N RHO                                  938+ 776
P6       N*3/2(1650) INTO N RHO,S=1/2,S-WAVE                     938+ 776
P7       N*3/2(1650) INTO N RHO,S=3/2,D-WAVE                     938+ 776
P8       N*3/2(1650) INTO N*1/2(1470) PI                        1470+ 139

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                         82   N*3/2(1650) BRANCHING RATIOS

R1       N*3/2(1650) INTO (PI N)/TOTAL                        (P1)
R1   3        (0.284)                      DONNACH1   68 RVUE                          6/68
R1   6        (0.317)                      AYED       70 IPWA                          1/71
R1   4        (0.28)                       DAVIES     70 RVUE     P-S ANAL   SOL A     8/69
R1   7        (0.35)                       ALMEHED    72 IPWA                          2/72
R1             (.32)                       AYED       76 IPWA                         11/77
R1               .25        .04            CUTKOSKY   79 IPWA     PI N TO PI N        12/79*
R1               .35        .06            HOEHLER    79 IPWA     PI N TO PI N        12/79*
R1             . . . . . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

R2       N*3/2(1650) FROM PI N TO N*3/2(1232) PI              SQRT(P1*P4)         11/75
R2    L        (+.40)OR  +.40              LONGACRE   75 IPWA     PI N TO 2PI N       11/75
R2   8         (+.39)                      LONGACRE   77 IPWA     PI N TO 2PI N       11/77
R2   8    LCNGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R2    5         +.33        .06            BARNHAM    79 IPWA ++  PI N TO 2PI N       12/79*
R2    5   THE COUPLING SIGNS (WHERE DETERMINED) OF BARNHAM 79 HAVE BEEN               12/79*
R2    5   CHANGED TO AGREE WITH THE CONVENTICN OF LONGACRE 77.                        12/79*

R3       N*3/2(1650) FROM PI N TO N RHO,S=1/2,S-WAVE          SQRT(P1*P6)         11/75
R3    L        (.18)OR  -.28               LONGACRE   75 IPWA     PI N TO 2PI N       11/75
R3   8         (-.08)                      LONGACRE   77 IPWA     PI N TO 2PI N       11/77
R3    5         -.40        .10            BARNHAM    79 IPWA ++  PI N TO 2PI N       12/79*

R4       N*3/2(1650) FROM PI N TO N RHO,S=3/2,D-WAVE          SQRT(P1*P7)         11/77
R4   8         (+.13)                      LONGACRE   77 IPWA     PI N TO 2PI N       11/77

R5       N*3/2(1650) FROM PI N TO N*1/2(1470) PI              SQRT(P1*P8)         12/79*
R5    5          .11        .05            BARNHAM    79 IPWA ++  PI N TO 2PI N       12/79*

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                         82   N*3/2(1650) PHOTCN DECAY AMPL(GEV**-1/2)

         FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
       REVIEW PRECEDING THE BARYON LISTINGS.

A1       N*3/2(1650) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)
A1              .004        .033           DEVENISH   73 DPWA     PI N PHOTO PROD      2/74
A1             (.113)                      HEMMI1     73        + FWD PIO PHTOPROD     2/74
A1             +.090        .076           MOORHOUS   73 DPWA     PI N PHOTC-PROD      2/73
A1             -.10         .017           DEVENIS2   74 DPWA     PI N PHOTO-PROD      4/75
A1              .033        .015           KNIES      74 DPWA     PI N PHOTO PROD      2/74
A1              .105        .038           METCALF    74 DPWA     PI N PHOTO-PROD      2/74
A1              .078        .066           MOORHOUS   74 DPWA     PI N PHOTO-PROD      2/74
A1             +.044        .027           CRAWFORD   75 DPWA     PI N PHOTO-PROD      1/76
A1            (+.058)                      KRIVETS    75 DPWA     PI-N PHOTO-PROD      1/78
A1            (+.055)                      BARBOUR    76 DPWA     PI N PHOTO-PROD      1/76
A1             -.005        .016           FELLER     76 DPWA     PI N PHOTO-PROD      2/77
A1             -.014        .030           AZNAURYAN  77 DPWA     PIO PHTPRD,SOL 1    12/79*
A1              .000        .014           AZNAURYAN  77 DPWA     PIO PHTPRD,SOL 2    12/79*
A1   2         +.034        .028           BARBOUR    78 DPWA     PI-N PHOTO-PROD      3/79*
A1             . . . . . . . . . .
A1   AVERAGE MEANINGLESS (SCALE FACTOR = 2.4)

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                                 REFERENCES FOR N*3/2(1650)

DEVLIN    65 PRL 14 1031          T J DEVLIN,J SOLOMON,G BERTSCH   (PRINCETON) I

BAREYRE   68 PR 165 1731          P BAREYRE, C BRICMAN, G VILLET        (SACLAY)IJP
DCNNACH1  68 PL 26B 161           A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
     ALSO 68 VIENNA 139           DONNACHIE  RAPPORTEUR'S TALK             (GLAS)
     ALSO 68 THESIS               R G KIRSOPP                              (ECIN)

AYED      70 KIEV CCNF            R AYED,P BAREYRE, G VILLET             (SACL)IJP
DAVIES    70 NP B21 359           A DAVIES                                 (GLAS)

ALMEHED   72 NP B40 157           +LOVELACE                          (LUND,RUTG)IJP
DEVENISH  73 PL 47B 53            DEVENISH,RANKIN,LYTH         (LOUC+BONN+LANC)IJP
HEMMI1    73 PL 43B 79            HEMMI,INAGAKI+            (KYOTO+SAGA+KEK+TOKY)IJP
MOORHOUS  73 PL 43B 44            MOORHOUSE, OBERLACK                (GLAS+LBL)IJP

DEVENIS2  74 PL 52B 227           DEVENISH,LYTH,RANKIN           (DESY,LANC,BCNN)IJP
KNIES     74 PRD 9 2680           KNIES,MOORHOUSE,OBERLACK            (LBL,GLAS)IJP
METCALF   74 NP B76 253           W J METCALF,R L WALKER                    (CIT)IJP
MOORHOUS  74 PRD 9 1              MOORHOUSE,OBERLACK,ROSENFELD       (GLAS+LBL)IJP

CRAWFORD  75 NP B97 125           R L CRAWFORD                             (GLAS)IJP
KRIVETS   75 SJNP 20 430          +MIROSHNICHENKO,NIKIFOROV,SANIN+         (KIEV)IJP
     ALSO 74 SJNP 19 112          KRIVETS,NIKIFOROV,SANIN,SHALATSKII       (KIEV)IJP
LONGACRE  75 PL 55B 415           +ROSENFELD,LASINSKI,SMADJA+          (LBL,SLAC)IJP
     ALSO 78 PRD 17 1795          LONGACRE,LASINSKI,ROSENFELD+         (LBL,SLAC)

AYED      76 CEA-N-1921           AYED (THESIS)                            (SACL)IJP
BARBOUR   76 NP B111 358          I. M. BARBOUR,R. L. CRAWFORD             (GLAS)IJP
FELLER    76 NP B104 219          +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP

AZNAURYA  77  EFI-264(57)-77      +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
LONGACRE  77 NP B122 493          LONGACRE,DOLBEAU                         (SACL)IJP
     ALSO 76 NP B108 365          DOLBEAU,TRIANTIS,NEVEU,CADIET            (SACL)IJP

BARBOUR   78 NP B141 253          BARBOUR,CRAWFORD,PARSONS                 (GLAS)
BARNHAM   79  IC/HENP/78/3        +GLICKMAN,MIER-JEDRZEJOWICZ+             (LCIC)IJP
CUTKOSKY  79 PRD 20 2839          +FORSYTH,HENDRICK,KELLY              (CARN+LBL)IJP
HOEHLER   79 HANDBOCK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                  +KAISER,KOCH,PIETARINEN           /KARLSRUHE IJP

                                  PAPERS NOT REFERRED TO IN DATA CARDS

CARRUTHE  60 PRL 4 303            P CARRUTHERS                         (CORNELL) I
DEVLIN    62 PR 125 690           T J DEVLIN, B J MOYER, V PEREZ-MENDEZ (LRL) I
HELLAND   64 PR 134 B1062         +DEVLIN,HAGGE,LONGO,MOYER,WOOD           (LRL) I
BAREYRE   65 PL 18 342            + BRICMAN, STIRLING, VILLET          (SACLAY)IJP
JOHNSON   67 UCRL-17683 THESIS C H JOHNSON                              (LRL)
DONNACHI  69 NP 10B 433           A DONNACHIE, R KIRSOPP              (GLAS+EDIN)
AYED      70 PL 31B 598           +BAREYRE,VILLET                        (SACLAY)
BOWLER    70 NP 17B 331           +CASHMORE                           (U. OXFCRD)
DEANS     75 NP B96 90            +MITCHELL,MCNTGOMERY,+          (SFLA,ALABAMA)IJP
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Δ(1670) 10   N*3/2(1670, JP=3/2-) I=3/2 **D_{33}**

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                    10   N*3/2(1670) MASS (MEV)

M    3      (1691.0)                    DONNACH1   68 RVUE     PHASE-SHIFT ANAL   8/69
M    6   ENER. DEP. FIT OF ARGAND DIAGRAM
M    4      (1649.0)                    DAVIES     70 RVUE     P-S ANAL   SOL A   8/69
M    7      (1700.)                     ALMEHED    72 IPWA                        2/72
M             1612. TO 1624.            CRAWFORD   75 DPWA     PI N PHOTO-PROD    1/76
M           (1600.)    (10.)            GAIDOS     75 HBC   ++ PI+P TO N* 2PI     1/76
M     L       1725. OR 1680.            LONGACRE   75 IPWA     PI N TO 2PI N     11/75
M     L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.       11/75
M           (1723.)                     AYED       76 IPWA                       11/77
M           (1629.)                     BARBOUR    76 DPWA     PI N PHOTO-PROD    1/76
M    8      (1600.)                     LONGACRE   77 IPWA     PI N TO 2PI N     11/77
M    8   ALL LONGACRE77 PARAMETERS ARE FRCM SOLUTICN S2, EXCEPT FOR THE POLE 11/77
M    8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                           11/77
M     5     (1629.)                     BARBOUR    78 DPWA     PI-N PHOTO-PROD    3/79*
M     5  SUPERSEDES BARBOUR 76.                                                 3/79*
M     9     (1650.)                     BARNHAM    79 IPWA ++  PI N TO 2PI N     12/79*
M             1730.       30.           CUTKOSKY   79 IPWA     PI N TO PI N      12/79*
M             1680.       70.           HOEHLER    79 IPWA     PI N TO PI N      12/79*
M             . . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                    10   N*3/2(1670) WIDTH (MEV)

W    3       (269.0)                    DONNACH1   68 RVUE                        8/69
W    6       (258.0)                    AYED       70 IPWA                        1/71
W    4       (188.0)                    DAVIES     70 RVUE     SOL A              8/69
W    7       (260.)                     ALMEHED    72 IPWA                        2/72
W              210. TO  268.            CRAWFORD   75 DPWA     PI N PHOTO-PROD    1/76
W            (180.)    (35.)    (20.)   GAIDOS     75 HBC   ++ PI+P TO N* 2PI     1/76
W     L        190. OR  240.            LONGACRE   75 IPWA     PI N TO 2PI N     11/75
W            (192.)                     AYED       76 IPWA                       11/77
W            (222.)                     BARBOUR    76 DPWA     PI N PHOTO-PROD    1/76
W    8       (200.)                     LONGACRE   77 IPWA     PI N TO 2PI N     11/77
W     5      (216.)                     BARBOUR    78 DPWA     PI-N PHOTO-PROD    3/79*
W     9      (160.)                     BARNHAM    79 IPWA ++  PI N TO 2PI N     12/79*
W              300.        100.         CUTKOSKY   79 IPWA     PI N TO PI N      12/79*
W              230.         80.         HOEHLER    79 IPWA     PI N TO PI N      12/79*
W             . . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
          SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                    10   N*3/2(1670) REAL PART OF POLE POSITION (MEV)        11/75

RE          (1681.)                     LONGACRE   75 IPWA     PI N TO 2PI N     11/75
RE   8        1600. OR 1594.            LONGACRE   77 IPWA     PI N TO 2PI N     11/77
RE          (1691.)                     CUTKOSKY   79 IPWA     PI N TO PI N      12/79*

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                    10   N*3/2(1670) -2*IMAG PART OF PCLE POSITION (MEV)     11/75

IM           (245.)                     LONGACRE   75 IPWA     PI N TO 2PI N     11/75
IM   8         208. OR 201.             LONGACRE   77 IPWA     PI N TO 2PI N     11/77
IM           (292.)                     CUTKOSKY   79 IPWA     PI N TO PI N      12/79*

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Data Card Listings

For notation, see key at front of Listings.

Baryons

Δ(1670), Δ(1690)

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              10  N*3/2(1670) REAL PART OF ELASTIC POLE RESIDUE (MEV)
RER         (24.)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
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              10  N*3/2(1670) IMAG PART OF ELASTIC POLE RESIDUE (MEV)
IMR         (-2.)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
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              10  N*3/2(1670) PARTIAL DECAY MODES
                                                        DECAY MASSES
P1     N*3/2(1670) INTO PI N                            139+ 938
P2     N*3/2(1670) INTO N PI PI                         938+ 139+ 139
P3     N*3/2(1670) INTO K SIGMA                         493+1189
P4     N*3/2(1670) INTO GAM NUCLEON, HELICITY=1/2         0+ 938
P5     N*3/2(1670) INTO GAM NUCLEON, HELICITY=3/2         0+ 938
P6     N*3/2(1670) INTO N*3/2(1232) PI                 1232+ 139
P7     N*3/2(1670) INTO N*3/2(1232) PI,S-WAVE          1232+ 139
P8     N*3/2(1670) INTO N*3/2(1232) PI,D-WAVE          1232+ 139
P9     N*3/2(1670) INTO N RHO,S=3/2,S-WAVE              938+ 776
P10    N*3/2(1670) INTO N RHO,S=1/2,D-WAVE              938+ 776
P11    N*3/2(1670) INTO N RHO,S=3/2,D-WAVE              938+ 776
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              10  N*3/2(1670) BRANCHING RATIOS

R1     N*3/2(1670) INTO (PI N)/TOTAL                   (P1)
R1  3       (0.14)                 DONNACH1  68 RVUE                       8/69
R1  6       (0.217)                AYED      70 IPWA                       1/71
R1  4       (0.12)                 DAVIES    70 RVUE    SOL A              8/69
R1  7       (0.16)                 ALMEHED   72 IPWA                       2/72
R1          (.17)                  AYED      76 IPWA                      11/77
R1            .12       .04        CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
R1            .20       .03        HOEHLER   79 IPWA    PI N TO PI N     12/79*
R1          . . . . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

R2     N*3/2(1670) INTO (K SIGMA)/TOTAL                (P3)
R2  1       (.00002)OR LESS        FEUERBACH 70 RVUE    PI P TO K+ SIG+    7/70
R2  1    ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68
R2  1    MODEL USED MAY DOUBLE COUNT.

R3     N*3/2(1670) FROM PI N TO N*3/2(1232) PI,S-WAVE   SQRT(P1*P7)       11/75
R3  L       (-.25)OR  -.24         LONGACRE  75 IPWA    PI N TO 2PI N     11/75
R3  8       (-.30)                 LONGACRE  77 IPWA    PI N TO 2PI N     11/77
R3  8  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R3  9       -.18        .04        BARNHAM   79 IPWA ++ PI N TO 2PI N     12/79*
R3  9  THE COUPLING SIGNS (WHERE DETERMINED) OF BARNHAM 79 HAVE BEEN      12/79*
R3  9  CHANGED TO AGREE WITH THE CONVENTION OF LONGACRE 77.               12/79*

R4     N*3/2(1670) FROM PI N TO N*3/2(1232) PI,D-WAVE   SQRT(P1*P8)       11/75
R4  L       (0.) OR  (-.10)        LONGACRE  75 IPWA    PI N TO 2PI N     11/75
R4  8       (-.05)                 LONGACRE  77 IPWA    PI N TO 2PI N     11/77
R4  9        .14        .04        BARNHAM   79 IPWA ++ PI N TO 2PI N     12/79*

R5     N*3/2(1670) FROM PI N TO N RHO,S=3/2,S-WAVE      SQRT(P1*P9)       11/75
R5  L       (.20)OR  +.30          LONGACRE  75 IPWA    PI N TO 2PI N     11/75
R5  8       (-.04)                 LONGACRE  77 IPWA    PI N TO 2PI N     11/77

R6     N*3/2(1670) FROM PI N TO K SIGMA                 SQRT(P1*P3)       11/75
R6  2       (.001)TO   .011        DEANS     75 DPWA    PI N TO K SIGMA   11/75
R6  2  RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                           11/75
R6  2  DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77          1/78
R6  2  AROUND 1920 MEV.                                                    1/78

R7     N*3/2(1670) FROM PI N TO N RHO,S=1/2,D-WAVE      SQRT(P1*P10)      12/79*
R7  9       -.17        .05        BARNHAM   79 IPWA ++ PI N TO 2PI N     12/79*

R8     N*3/2(1670) FROM PI N TO N RHO,S=3/2,D-WAVE      SQRT(P1*P11)      12/79*
R8  9        .18        .07        BARNHAM   79 IPWA ++ PI N TO 2PI N     12/79*
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              10  N*3/2(1670) PHOTON DECAY AMPL(GEV**-1/2)

   FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
  REVIEW PRECEDING THE BARYON LISTINGS.

A1     N*3/2(1670) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)
A1            .036      .052       DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A1          +.068       .042       MOORHOUS  73 DPWA    PI N PHOTO-PROD    2/73
A1            .054      .029       DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A1            .078      .009       KNIES     74 DPWA    PI N PHOTO PROD    2/74
A1            .0        .048       METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A1            .041      .028       MOORHOUS  74 DPWA    PI N PHOTO-PROD    2/74
A1          +.101       .011       CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A1          (+.120)                BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A1          +.072       .033       FELLER    76 DPWA    PI N PHOTO-PROD    2/77
A1          +.147       .013       AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79*
A1          +.136       .013       AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79*
A1  5       +.130       .037       BARBOUR   78 DPWA    PI-N PHOTO-PROD    3/79*
A1          . . . . . . . . .
A1   AVERAGE MEANINGLESS (SCALE FACTOR = 2.1)

A2     N*3/2(1670) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)
A2            .110      .039       DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A2          +.022       .052       MOORHOUS  73 DPWA    PI N PHOTO-PROD    2/73
A2            .072      .014       DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A2            .070      .009       KNIES     74 DPWA    PI N PHOTO PROD    2/74
A2            .0        .041       METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A2            .021      .020       MOORHOUS  74 DPWA    PI N PHOTO-PROD    2/74
A2          +.116       .024       CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A2          (+.117)                BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A2          +.087       .023       FELLER    76 DPWA    PI N PHOTO-PROD    2/77
A2          +.053       .003       AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79*
A2          +.022       .003       AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79*
A2  5       +.098       .036       BARBOUR   78 DPWA    PI-N PHOTO-PROD    3/79*
A2          . . . . . . . . .
A2   AVERAGE MEANINGLESS (SCALE FACTOR = 4.9)
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REFERENCES FOR N*3/2(1670)


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DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
   ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR'S TALK          (GLAS)
   ALSO 68 THESIS             R G KIRSOPP                           (EDIN)

AYED     70 KIEV CONF         R AYED,P BAREYRE, G VILLET            (SACL)IJP
DAVIES   70 NP B21 359        A DAVIES                              (GLAS)
FEUERBAC 70 NP 16B 85         FEUERBACHER+HOLLADAY            (VANDERBILT)
ALMEHED  72 NP B40 157        +LOVELACE                       (LUND,RUTG)IJP
DEVENISH 73 PL 47B 53         DEVENISH,RANKIN,LYTH      (LOUC+BONN+LANC)IJP
MOORHOUS 73 PL 43B 44         MOORHOUSE, OBERLACK             (GLAS+LBL)IJP

DEVENIS2 74 PL 52B 227        DEVENISH,LYTH,RANKIN        (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680        KNIES,MOORHOUSE,OBERLACK        (LBL,GLAS)IJP
METCALF  74 NP B76 253        W J METCALF,R L WALKER               (CIT)IJP
MOORHOUS 74 PRD 9 1           MOORHOUSE,OBERLACK,ROSENFELD    (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125        R L CRAWFORD                        (GLAS)IJP
DEANS    75 NP B96 90         +MITCHELL,MONTGOMERY,+     (SFLA,ALABAMA)IJP
GAIDOS   75 PRD 12 2565       GAIDOS,MILLER                       (PURD)IJP
LONGACRE 75 PL 55B 415        +ROSENFELD,LASINSKI,SMADJA+    (LBL,SLAC)IJP
   ALSO  78 PRD 17 1795       LONGACRE,LASINSKI,ROSENFELD+   (LBL,SLAC)

AYED     76 CEA-N-1921        AYED (THESIS)                       (SACL)IJP
BARBOUR  76 NP B111 358       I. M. BARBOUR,R. L. CRAWFORD        (GLAS)IJP
FELLER   76 NP B104 219       +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP

AZNAURYA 77  EFI-264(57)-77   +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
LONGACRE 77 NP B122 493       LONGACRE,DOLBEAU                    (SACL)IJP
   ALSO  76 NP B108 365       DOLBEAU,TRIANTIS,NEVEU,CADIET       (SACL)IJP

BARBOUR  78 NP B141 253       BARBOUR,CRAWFORD,PARSONS            (GLAS)
BARNHAM  79   IC/HENP/78/3    +GLICKMAN,MIER-JEDRZEJOWICZ+        (LOIC)IJP
CUTKOSKY 79 PRD 20 2839       +FORSYTH,HENDRICK,KELLY         (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN         /KARLSRUHE IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS

DONNACHI 69 NP 10B 433        A DONNACHIE, R KIRSOPP             (GLAS+EDIN)
AYED     70 PL 31B 598        +BAREYRE,VILLET                       (SACLAY)
BOWLER   70 NP 17B 331        +CASHMORE                          (U. OXFORD)
WINNIK   77 NP B128 66        +TOAFF,REVEL,GOLDBERG,BERNY             (HAIF)I
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Δ(1690) 19 N*3/2(1690, JP=3/2+) I=3/2 **P''_{33}**

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RECENT ANALYSES INDICATE AT LEAST ONE P33 RESONANCE
SOMEWHERE IN THE 1650-1900 MEV REGION.  IN ADDITION
TO THE STATE LISTED, THE ANALYSIS OF BARNHAM 79 IS
CONSISTENT WITH THE PRESENCE OF ANOTHER P33 RESONANCE
WITH MASS 1600 MEV AND WIDTH 80 MEV.  SEE ALSO THE
N*3/2(1960,JP=3/2+) LISTINGS.
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              19  N*3/2(1690) MASS (MEV)

M   3       (1690.)                DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
M   3       (1690.)                KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M   3  WHERE MAX. ABSORPTION IS -DONNACHI, 2 ,KIRSOPP EYEBALL FIT CERN 1  10/69
M   6       (1801.0)               AYED      70 IPWA                       1/71
M   6  ENER. DEP. FIT OF ARGAND DIAGRAM
M   7       (1680.)                ALMEHED   72 IPWA                       2/72
M    L       1900. OR 1640.        LONGACRE  75 IPWA    PI N TO 2PI N     11/75
M    L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M           (1900.)                AYED      76 IPWA                      11/77
M   8       (1560.)                LONGACRE  77 IPWA    PI N TO 2PI N     11/77
M   8  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M   8  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                        11/77
M    4      (1690.)                BARNHAM   79 IPWA ++ PI N TO 2PI N     12/79*
M            1640.       50.       CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
M            1522.       13.       HOEHLER   79 IPWA    PI N TO PI N     12/79*
M           . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)
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              19  N*3/2(1690) WIDTH (MEV)

W   3       (281.)                 DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
W   3       (240.)                 KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W   6       (598.0)                AYED      70 IPWA                       1/71
W   7       (220.)                 ALMEHED   72 IPWA                       2/72
W    L       205. OR  300.         LONGACRE  75 IPWA    PI N TO 2PI N     11/75
W           (204.)                 AYED      76 IPWA                      11/77
W   8       (180.)                 LONGACRE  77 IPWA    PI N TO 2PI N     11/77
W    4      (250.)                 BARNHAM   79 IPWA ++ PI N TO 2PI N     12/79*
W            370.        70.       CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
W            220.        40.       HOEHLER   79 IPWA    PI N TO PI N     12/79*
W           . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)
        SEE THE NOTES ACCOMPANYING MASSES QUOTED
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              19  N*3/2(1690) REAL PART OF POLE POSITION (MEV)            11/75

RE          (1609.)                LONGACRE  75 IPWA    PI N TO 2PI N     11/75
RE  8        1541. OR 1542.        LONGACRE  77 IPWA    PI N TO 2PI N     11/77
RE          (1547.)                CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
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              19  N*3/2(1690) -2*IMAG PART OF POLE POSITION (MEV)         11/75

IM          (323.)                 LONGACRE  75 IPWA    PI N TO 2PI N     11/75
IM  8        178. OR 178.          LONGACRE  77 IPWA    PI N TO 2PI N     11/77
IM          (230.)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
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              19  N*3/2(1690) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER         (-18.)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
AG
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              19  N*3/2(1690) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         (-11.)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
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Baryons
Δ(1690), Δ(1890)

Data Card Listings
For notation, see key at front of Listings.

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                19   N*3/2(1690) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N*3/2(1690) INTO PI N                           139+ 938
P2      N*3/2(1690) INTO K SIGMA                        493+1189
P3      N*3/2(1690) INTO N*3/2(1232) PI,P-WAVE         1232+ 139
P4      N*3/2(1690) INTO N*3/2(1232) PI,F-WAVE         1232+ 139
P5.     N*3/2(1690) INTO N RHO,S=1/2,P-WAVE             938+ 776
P6      N*3/2(1690) INTO N RHO,S=3/2,P-WAVE             938+ 776
P7      N*3/2(1690) INTO N*1/2(1470) PI                1470+ 139

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                19   N*3/2(1690) BRANCHING RATIOS

R1      N*3/2(1690) INTO (PI N)/TOTAL                    (P1)
R1  3          (.10)                   DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
R1  3          (.08)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1  6         (0.135)                  AYED      70 IPWA                      1/71
R1  7         (0.1)                    ALMEHED   72 IPWA                      2/72
R1             (.19)                   AYED      76 IPWA                     11/77
R1              .20        .04         CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
R1              .21        .06         HOEHLER   79 IPWA    PI N TO PI N     12/79*
R1          . . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R2      N*3/2(1690) INTO (K SIGMA)/TOTAL                 (P2)
R2  1        (.00002)OR LESS           FEUERBACH 70 RVUE    PI P TO K+ SIG+   7/70
R2  1       ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68
R2  1       MODEL USED MAY DOUBLE COUNT.

R3      N*3/2(1690) FROM PI N TO K SIGMA                SQRT(P1*P2)         11/75
R3  2          (.006)TO   .042         DEANS     75 DPWA    PI N TO K SIGMA  11/75
R3  2     RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                           11/75
R3  2     DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77          1/78
R3  2     AROUND 1920 MEV.                                                    1/78

R4      N*3/2(1690) FROM PI N TO N*3/2(1232) PI,P-WAVE   SQRT(P1*P3)        11/75
R4   L        (-.36)OR  -.30           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R4  8         (-.34)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R4  8     LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R4   M         (.3)                    NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79*
R4   M    BW FIT TO LONGACRE 75 IPWA, PHASE IS NEAR -90 DEGREES.              3/79*
R4   N         (.27)                   NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79*
R4   N    BW FIT TO NOVOSELLER 78 IPWA, PHASE IS NEAR -90 DEGREES. THIS FIT  12/79*
R4   N    ASSUMES THE MASS IS NEAR 1900 MEV.                                 12/79*
R4   4         -.24        .05         BARNHAM   79 IPWA ++ PI N TO 2PI N    12/79*
R4   4    THE COUPLING SIGNS (WHERE DETERMINED) OF BARNHAM 79 HAVE BEEN      12/79*
R4   4    CHANGED TO AGREE WITH THE CONVENTION OF LONGACRE 77.               12/79*

R5      N*3/2(1690) FROM PI N TO N*3/2(1232) PI,F-WAVE   SQRT(P1*P4)        11/77
R5  8         (+.07)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R6      N*3/2(1690) FROM PI N TO N RHO,S=1/2,P-WAVE      SQRT(P1*P5)        11/77
R6  8         (-.10)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R7      N*3/2(1690) FROM PI N TO N RHO,S=3/2,P-WAVE      SQRT(P1*P6)        11/77
R7  8         (-.10)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R8      N*3/2(1690) FROM PI N TO N*1/2(1470) PI          SQRT(P1*P7)        12/79*
R8   4         -.23        .04         BARNHAM   79 IPWA ++ PI N TO 2PI N    12/79*

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                19   N*3/2(1690) PHOTON DECAY AMPL(GEV**-1/2)

     FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
   REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*3/2(1690) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)
A1             .016        .055        DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A1            -.033        .037        DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A1             .003        .015        KNIES     74 DPWA    PI N PHOTO PROD    2/74
A1             .0          .038        METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A1             .0          .020        FELLER    76 DPWA    PI N PHOTO-PROD    2/77
A1            +.006        .018        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79*
A1            -.119        .014        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79*
A1             .000        .030        BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A1          . . . . . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 2.8)

A2      N*3/2(1690) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)
A2             .074        .064        DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A2             .008        .046        DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A2            -.034        .022        KNIES     74 DPWA    PI N PHOTO PROD    2/74
A2             .0          .033        METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A2             .0          .015        FELLER    76 DPWA    PI N PHOTO-PROD    2/77
A2            -.133        .042        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79*
A2            -.088        .037        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79*
A2             .000        .045        BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A2          . . . . . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

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                          REFERENCES FOR N*3/2(1690)

DONNACH2 68 VIENNA 139       DONNACHIE  RAPPORTEUR'S TALK          (GLAS)
KIRSOPP  68 THESIS           R G KIRSOPP                           (EDIN)

AYED     70 KIEV CCNF        R AYED,P BAREYRE, G VILLET          (SACL)IJP
FEUERBAC 70 NP 16B 85        FEUERBACHER+HOLLADAY            (VANDERBILT)
ALMEHED  72 NP B40 157       +LOVELACE                       (LUND,RUTG)IJP
DEVENISH 73 PL 47B 53        DEVENISH,RANKIN,LYTH        (LOUC+BONN+LANC)IJP

DEVENIS2 74 PL 52B 227       DEVENISH,LYTH,RANKIN        (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680       KNIES,MOORHOUSE,OBERLACK         (LBL,GLAS)IJP
METCALF  74 NP B76 253       W J METCALF,R L WALKER                (CIT)IJP

DEANS    75 NP B96 90        +MITCHELL,MONTGOMERY,+        (SFLA,ALABAMA)IJP
LCNGACRE 75 PL 55B 415       +ROSENFELD,LASINSKI,SMADJA+      (LBL, SLAC)IJP
   ALSO  78 PRD 17 1795      LONGACRE,LASINSKI,ROSENFELD+     (LBL,SLAC)

AYED     76 CEA-N-1921       AYED (THESIS)                        (SACL)IJP
FELLER   76 NP B104 219      +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP

AZNAURYA 77  EFI-264(57)-77  +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
LONGACRE 77 NP B122 493      LONGACRE,DOLBEAU                     (SACL)IJP
   ALSO  76 NP B108 365      DOLBEAU,TRIANTIS,NEVEU,CADIET        (SACL)IJP

BARBOUR  78 NP B141 253      BARBOUR,CRAWFORD,PARSONS                (GLAS)
NOVOSELL 78 NP B137 509      D. E. NOVOSELLER                   (CAL TECH)IJP
   ALSO  78 NP B137 445      D. E. NOVOSELLER                   (CAL TECH)IJP

BARNHAM  79  IC/HENP/78/3    +GLICKMAN,MIER-JEDRZEJOWICZ+           (LOIC)IJP
CUTKOSKY 79 PRD 20 2839      +FORSYTH,HENDRICK,KELLY            (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                             +KAISER,KOCH,PIETARINEN            /KARLSRUHE IJP

                             PAPERS NOT REFERRED TO IN DATA CARDS

AYED     70 PL 31B 598       +BAREYRE,VILLET                       (SACLAY)
BOWLER   70 NP 17B 331       +CASHMORE                          (U. OXFORD)
WINNIK   77 NP B128 66       +TOAFF,REVEL,GOLDBERG, BERNY           (HAIF)I
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Δ(1890) 11 N*3/2(1890, JP=5/2+) I=3/2 F_{35}

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                11   N*3/2(1890) MASS (MEV)

M   3     (1913.0)                    DONNACH1  68 RVUE    PHASE-SHIFT ANAL  8/69
M   6     (1837.0)                    AYED      70 IPWA                      1/71
M   6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   4     (1841.0)                    DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M   7     (1875.)                     ALMEHED   72 IPWA                      2/72
M    1     1890. TO 1986.             MEHTANI   72 DPWA    PI+P TO PI+PIOP   9/73
M   5     (1890.)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
M   5     (1890.)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
M   5   DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF      1/78
M   5   WINNIK77 AROUND 1920 MEV.                                            1/78
M    L     1870. OR 1830.             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.   11/75
M         (1869.)                     AYED      76 IPWA                     11/77
M          1885.       27.            CUTKOSKY  76 IPWA                     11/77
M    8    (1892.)                     BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
M    C     1920.       30.            CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
M    C  SUPERSEDES CUTKOSKY 76.                                             12/79*
M          1905.       20.            HOEHLER   79 IPWA    PI N TO PI N     12/79*
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                11   N*3/2(1890) WIDTH (MEV)

W   3      (350.0)                    DONNACH1  68 RVUE                      8/69
W   6      (198.0)                    AYED      70 IPWA                      1/71
W   4      (136.0)                    DAVIES    70 RVUE    SOL A             8/69
W   7      (250.)                     ALMEHED   72 IPWA                      2/72
W    1      273. TO 322.              MEHTANI   72 DPWA    PI+P TO PI+PIOP   9/73
W   5      (180.)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
W   5      (140.)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
W    L      255. OR  220.             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W          (255.)                     AYED      76 IPWA                     11/77
W           310.       90.            CUTKOSKY  76 IPWA                     11/77
W    8     (159.)                     BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
W    C      340.       80.            CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
W           260.       20.            HOEHLER   79 IPWA    PI N TO PI N     12/79*
W          . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
         SEE NOTES ACCOMPANYING MASSES QUOTED AS FOR N*1/2(1910)

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                11   N*3/2(1890) REAL PART OF POLE POSITION (MEV)          11/75

REE        (1813.)                    LONGACRE  75 IPWA    PI N TO 2PI N    11/75
REE         1825.      12.            CUTKOSKY  76 IPWA                     11/77
REE  C     (1865.)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                11   N*3/2(1890) -2*IMAG PART OF POLE POSITION (MEV)       11/75

IME        (193.)                     LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IME         250.       36.            CUTKOSKY  76 IPWA                     11/77
IME  C     (266.)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
GV

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                11   N*3/2(1890) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          13.5      3.5            CUTKOSKY  76 IPWA                     11/77
RER  C      (20.)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                11   N*3/2(1890) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         -11.       5.             CUTKOSKY  76 IPWA                     11/77
IMR  C      (-5.)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                11   N*3/2(1890) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      N*3/2(1890) INTO PI N                            139+ 938
P2      N*3/2(1890) INTO N PI PI                         938+ 139+ 139
P3      N*3/2(1890) INTO K SIGMA                         493+1189
P4      N*3/2(1890) INTO N*3/2(1232) PI                 1232+ 139
P5      N*3/2(1890) INTO GAM NUCLEON, HELICITY=1/2         0+ 938
P6      N*3/2(1890) INTO GAM NUCLEON, HELICITY=3/2         0+ 938
P7      N*3/2(1890) INTO N RHO                           938+ 776
P8      N*3/2(1890) INTO N*3/2(1232) PI,P-WAVE          1232+ 139
P9      N*3/2(1890) INTO N*3/2(1232) PI,F-WAVE          1232+ 139
P10     N*3/2(1890) INTO N RHO,S=3/2,P-WAVE              938+ 776

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Data Card Listings

For notation, see key at front of Listings.

Baryons

Δ(1890), Δ(1900), Δ(1910)

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                    11   N*3/2(1890) BRANCHING RATIOS

R1      N*3/2(1890) INTO (PI N)/TOTAL                            (P1)
R1  3          (0.16)                  DONNACH1  68 RVUE                        8/69
R1  6          (0.147)                 AYED      70 IPWA                        1/71
R1  4          (0.20)                  DAVIES    70 RVUE     SOL A              8/69
R1  7          (0.18)                  ALMEHED   72 IPWA                        2/72
R1              (.14)                  AYED      76 IPWA                       11/77
R1               .140      .008        CUTKOSKY  76 IPWA                       11/77
R1   C           .15       .02         CUTKOSKY  79 IPWA     PI N TO PI N      12/79*
R1               .15       .02         HOEHLER   79 IPWA     PI N TO PI N      12/79*
R1           . . . . . . . . . .
R1  AVG        0.1424    0.0070   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT    0.1424    0.0076   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
GV

R2      N*3/2(1890) INTO (K SIGMA)/TOTAL                         (P3)
R2  1          (0.008)OR LESS          FEUERBACH 70 RVUE     PI P TO K+ SIG+    7/70
R2  1       ASSUME MASS, WIDTH, X(ELAST) CF DONNACHIE 68
R2  1       MODEL USED MAY DOUBLE COUNT.

R3      N*3/2(1890) INTO (SIGMA K)*(PI N)/TOTAL**2               (P3*P1)
R3              (.0016)OR LESS         KALMUS    70 DPWA     PI+P TO K+ SIG+    1/71

R4      N*3/2(1890) FROM PI N TO N*3/2(1232) PI                 SQRT(P1*P4)
R4  1       .19 TO .23                 MEHTANI   72 DPWA     PI+P TO PI+PIOP    9/73
R4  1   MOSTLY F WAVE DECAY                                                     9/73

R5      N*3/2(1890) FROM PI N TO K SIGMA                        SQRT(P1*P3)     9/73
R5  5           (.06)                  LANGBEIN  73 IPWA     PI N-K SIG,SOL 1   9/73
R5  5           (.06)                  LANGBEIN  73 IPWA     PI N-K SIG,SOL 2   9/73
R5  2           (.021)TO  .054         DEANS     75 DPWA     PI N TO K SIGMA   11/75
R5  2   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                               11/75

R6      N*3/2(1890) FROM PI N TO N*3/2(1232) PI,F-WAVE   SQRT(P1*P9)          11/75
R6  L          (-.12)OR  -.20          LONGACRE  75 IPWA     PI N TO 2PI N     11/75
R6  M          (-.17)                  NOVOSELLE 78 IPWA     PI N TO 2PI N      3/79*
R6  M   BW FIT TO LONGACRE 75 IPWA.                                             3/79*
R6  N          (-.06)                  NOVOSELLE 78 IPWA     PI N TO 2PI N      3/79*
R6  N   BW FIT TO NOVOSELLER 78 IPWA.                                           3/79*

R7      N*3/2(1890) FROM PI N TO N RHO,S=3/2,P-WAVE      SQRT(P1*P10)         11/75
R7  L          (-.28)OR  -.33          LONGACRE  75 IPWA     PI N TO 2PI N     11/75
R7  M          (-.26)                  NOVOSELLE 78 IPWA     PI N TO 2PI N      3/79*
R7  9          (-.11)TO -.33           NOVOSELLE 78 IPWA     PI N TO 2PI N      3/79*
R7  9   BW FIT TO NOVOSELLER 78 IPWA, PHASE IS NEAR 90 DEGREES.                12/79*

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                    11   N*3/2(1890) PHOTON DECAY AMPL(GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*3/2(1890) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)
A1             .019      .027          DEVENIS2  74 DPWA     PI N PHOTO-PROD    4/75
A1             .042      .016          KNIES     74 DPWA     PI N PHOTO PROD    2/74
A1            +.047      .067          METCALF   74 DPWA     PI N PHOTO-PROD    2/74
A1            -.003      .009          CRAWFORD  75 DPWA     PI N PHOTO-PROD    1/76
A1           (+.035)                   BARBOUR   76 DPWA     PI N PHOTO-PROD    1/76
A1            -.001      .012          AZNAURYAN 77 DPWA     PIO PHTPRD,SOL 1 12/79*
A1            +.063      .018          AZNAURYAN 77 DPWA     PIO PHTPRD,SOL 2 12/79*
A1  8         +.033      .018          BARBOUR   78 DPWA     PI-N PHOTO-PROD    3/79*
A1  8   SUPERSEDES BARBOUR 76.                                                  3/79*
A1           . . . . . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.8)

A2      N*3/2(1890) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)
A2             .078      .020          DEVENIS2  74 DPWA     PI N PHOTO-PROD    4/75
A2            -.022      .020          KNIES     74 DPWA     PI N PHOTO PROD    2/74
A2            -.028      .066          METCALF   74 DPWA     PI N PHOTO-PROD    2/74
A2            -.021      .036          CRAWFORD  75 DPWA     PI N PHOTO-PROD    1/76
A2           (-.013)                   BARBOUR   76 DPWA     PI N PHOTO-PROD    1/76
A2            -.094      .027          AZNAURYAN 77 DPWA     PIO PHTPRD,SOL 1 12/79*
A2            -.101      .018          AZNAURYAN 77 DPWA     PIO PHTPRD,SOL 2 12/79*
A2  8         -.055      .019          BARBOUR   78 DPWA     PI-N PHOTO-PROD    3/79*
A2           . . . . . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 2.9)

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REFERENCES FOR N*3/2(1890)


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DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR'S TALK          (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                           (EDIN)

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET            (SACL)IJP
DAVIES   70 NP B21 359         A DAVIES                              (GLAS)
FEUERBAC 70 NP 16B 85          FEUERBACHER+HOLLADAY            (VANDERBILT)
KALMUS   70 PR D2 1824         G KALMUS, G BORREANI, J LOUIE          (LRL)

ALMEHED  72 NP B40 157         +LOVELACE                        (LUND,RUTG)IJP
MEHTANI  72 PRL 29 1634        +FUNG, KERNAN, SCHALK, +          (UCR +LBL)
LANGBEIN 73 NP B53 251         LANGBEIN,WAGNER                     (MUNICH)IJP
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN         (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680         KNIES,MOORHOUSE,OBERLACK          (LBL,GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                 (CIT)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                          (GLAS)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+         (SFLA,ALABAMA)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+       (LBL,SLAC)IJP
    ALSO 78 PRD 17 1795        LONGACRE,LASINSKI,ROSENFELD+      (LBL,SLAC)

AYED     76 CEA-N-1921         AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358        I. M. BARBOUR,R. L. CRAWFORD          (GLAS)IJP
CUTKOSKY 76 PRL 37 645         CUTKOSKY,HENDRICK,KELLY           (CARN+LBL)IJP
    ALSO 76 OXFORD CONF. 49    CUTKOSKY,HENDRICK,CHAO+      (CARN+LBL+BRIS)IJP
AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP

BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS              (GLAS)
NOVOSELL 78 NP B137 509        D. E. NOVOSELLER                  (CAL TECH)IJP
    ALSO 78 NP B137 445        D. E. NOVOSELLER                  (CAL TECH)IJP

CUTKOSKY 79 PRD 20 2839        +FORSYTH,HENDRICK,KELLY           (CARN+LBL)IJP
HOEHLER  79 HANDBOCK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN          /KARLSRUHE IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS

AYED     70 PL 31B 598         +BAREYRE+VILLET                     (SACLAY)
WINNIK   77 NP B128 66         +TOAFF,REVEL,GOLDBERG,BERNY           (HAIF)I
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Δ(1900) S''_{31}

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        30   N*3/2(1900, JP=1/2-) I=3/2                                      9/73
        THIS EFFECT IS SEEN IN TWO CHANNELS.

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                    30   N*3/2(1900) MASS (MEV)                              9/73

M   2      (1920.)                     LANGBEIN  73 IPWA     PI N-K SIG,SOL 1   9/73
M   2      (1870.)                     LANGBEIN  73 IPWA     PI N-K SIG,SOL 2   9/73
M   2   DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF         1/78
M   2   WINNIK77 AROUND 1920 MEV.                                               1/78
M          (2001.)                     AYED      76 IPWA                       11/77
M           1850.       35.            CUTKOSKY  79 IPWA     PI N TO PI N      12/79*
M           1908.       30.            HOEHLER   79 IPWA     PI N TO PI N      12/79*
M            . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

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                    30   N*3/2(1900) WIDTH (MEV)                             9/73

W   2      (140.)                      LANGBEIN  73 IPWA     PI N-K SIG,SOL 1   9/73
W   2      (160.)                      LANGBEIN  73 IPWA     PI N-K SIG,SOL 2   9/73
W          (307.)                      AYED      76 IPWA                       11/77
W           130.        40.            CUTKOSKY  79 IPWA     PI N TO PI N      12/79*
W           140.        40.            HOEHLER   79 IPWA     PI N TO PI N      12/79*
W            . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
         SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                    30   N*3/2(1900) REAL PART OF POLE POSITION  (MEV)

REE        (1844.)                     CUTKOSKY  79 IPWA     PI N TO PI N      12/79*

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                    30   N*3/2(1900) -2*IMAG PART OF PCLE POSITION  (MEV)

IME        (142.)                      CUTKOSKY  79 IPWA     PI N TO PI N      12/79*

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                    30   N*3/2(1900) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          (7.)                      CUTKOSKY  79 IPWA     PI N TO PI N      12/79*

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                    30   N*3/2(1900) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         (-1.)                      CUTKOSKY  79 IPWA     PI N TO PI N      12/79*

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                    30   N*3/2(1900) PARTIAL DECAY MODES                     9/73

                                                          DECAY MASSES
P1      N*3/2(1900) INTO PI N                            139+ 938
P2      N*3/2(1900) INTO K SIGMA                         493+1189

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                    30   N*3/2(1900) BRANCHING RATIOS                        9/73

R1      N*3/2(1900) FROM PI N TO K SIGMA                        SQRT(P1*P2)     9/73
R1  2           (.11)                  LANGBEIN  73 IPWA     PI N-K SIG,SOL 1   9/73
R1  2           (.12)                  LANGBEIN  73 IPWA     PI N-K SIG,SOL 2   9/73
R1  1           (.076)                 DEANS     75 DPWA     PI N TO K SIGMA   11/75
R1  1   VALUE GIVEN IS FROM SOLUTION 1, NOT PRESENT IN SOLUTIONS 2,3,4.       11/75

R2      N*3/2(1900) INTO PI N/TOTAL                              (P1)
R2              (.08)                  AYED      76 IPWA                       11/77
R2               .08       .03         CUTKOSKY  79 IPWA     PI N TO PI N      12/79*
R2               .08       .04         HOEHLER   79 IPWA     PI N TO PI N      12/79*
R2           . . . . . . . . . .
R2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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REFERENCES FOR N*3/2(1900)


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LANGBEIN 73 NP B53 251         LANGBEIN,WAGNER                     (MUNICH)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+         (SFLA,ALABAMA)IJP
AYED     76 CEA-N-1921         AYED (THESIS)                         (SACL)IJP

CUTKOSKY 79 PRD 20 2839        +FORSYTH,HENDRICK,KELLY           (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN          /KARLSRUHE IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS

WINNIK   77 NP B128 66         +TOAFF,REVEL,GOLDBERG,BERNY           (HAIF)I
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Δ(1910) P''_{31}

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        12   N*3/2(1910, JP=1/2+) I=3/2
        THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                    12   N*3/2(1910) MASS (MEV)

M   3      (1934.0)                    DONNACH1  68 RVUE     PHASE-SHIFT ANAL   8/69
M   6      (1783.0)                    AYED      70 IPWA                        1/71
M   6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   4      (1914.0)                    DAVIES    70 RVUE     P-S ANAL  SOL A    8/69
M   7      (1900.)                     ALMEHED   72 IPWA                        2/72
M   9      (1980.)                     LANGBEIN  73 IPWA     PI N-K SIG,SOL 1   9/73
M   9      (1950.)                     LANGBEIN  73 IPWA     PI N-K SIG,SOL 2   9/73
M   9   DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF         1/78
M   9   WINNIK77 AROUND 1920 MEV.                                               1/78
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Baryons
Δ(1910), Δ(1950)

Data Card Listings
For notation, see key at front of Listings.

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M          (1789.)                          AYED       76 IPWA                      11/77
M           1940.      30.                  CUTKOSKY   76 IPWA                      11/77
M    8     (1790.)                          LONGACRE   77 IPWA   PI N TO 2PI N      11/77
M    8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                            11/77
M     5    (1899.)                          BARBOUR    78 DPWA   PI-N PHOTO-PROD     3/79*
M     C     1920.      50.                  CUTKOSKY   79 IPWA   PI N TO PI N       12/79*
M     C  SUPERSEDES CUTKOSKY 76.                                                   12/79*
M           1888.      20.                  HOEHLER    79 IPWA   PI N TO PI N       12/79*
M           . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
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              12  N*3/2(1910) WIDTH (MEV)

W    3      (339.0)                         DONNACH1   68 RVUE                       8/69
W    6      (308.0)                         AYED       70 IPWA                       1/71
W    4      (290.)                          DAVIES     70 RVUE   SOL A               8/69
W    7      (200.)                          ALMEHED    72 IPWA                       2/72
W    9      (190.)                          LANGBEIN   73 IPWA   PI N-K SIG,SOL 1    9/73
W    9      (170.)                          LANGBEIN   73 IPWA   PI N-K SIG,SOL 2    9/73
W           (221.)                          AYED       76 IPWA                      11/77
W            380.      130.                 CUTKOSKY   76 IPWA                      11/77
W    8      (170.)                          LONGACRE   77 IPWA   PI N TO 2PI N      11/77
W     5     (230.)                          BARBOUR    78 DPWA   PI-N PHOTO-PROD     3/79*
W     C      300.      100.                 CUTKOSKY   79 IPWA   PI N TO PI N       12/79*
W            280.       50.                 HOEHLER    79 IPWA   PI N TO PI N       12/79*
W           . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
            SEE NOTES ACCOMPANYING MASSES QUOTED
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              12  N*3/2(1910) REAL PART OF POLE POSITICN (MEV)

REE         1863.      15.                  CUTKOSKY   76 IPWA                      11/77
REE 8       1792. OR 1801.                  LONGACRE   77 IPWA   PI N TO 2PI N      11/77
REE  C     (1871.)                          CUTKOSKY   79 IPWA   PI N TO PI N       12/79*
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              12  N*3/2(1910) -2*IMAG PART OF POLE POSITION (MEV)

IME          250.      34.                  CUTKOSKY   76 IPWA                      11/77
IME 8        172. OR 165.                   LONGACRE   77 IPWA   PI N TO 2PI N      11/77
IME  C      (200.)                          CUTKOSKY   79 IPWA   PI N TO PI N       12/79*
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              12  N*3/2(1910) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          -4.        5.                  CUTKOSKY   76 IPWA                      11/77
RER  C      (-.6)                           CUTKOSKY   79 IPWA   PI N TO PI N       12/79*
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              12  N*3/2(1910) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         -27.        5.                  CUTKOSKY   76 IPWA                      11/77
IMR  C      (-18.)                          CUTKOSKY   79 IPWA   PI N TO PI N       12/79*
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              12  N*3/2(1910) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1       N*3/2(1910) INTO PI N                             139+ 938
P2       N*3/2(1910) INTO N PI PI                          938+ 139+ 139
P3       N*3/2(1910) INTO K SIGMA                          493+1189
P4       N*3/2(1910) INTC N*3/2(1232) PI                  1232+ 139
P5       N*3/2(1910) INTO GAM NUCLEON, HELICITY=1/2          0+ 938
P6       N*3/2(1910) INTO N RHO,S=3/2                      938+ 776
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              12  N*3/2(1910) BRANCHING RATIOS

R1       N*3/2(1910) INTO (PI N)/TOTAL                      (P1)
R1  3        (0.30)                         DONNACH1   68 RVUE                       8/69
R1  6        (0.128)                        AYED       70 IPWA                       1/71
R1  4        (0.18)                         DAVIES     70 RVUE   SOL A               8/69
R1  7        (0.33)                         ALMEHED    72 IPWA                       2/72
R1            (.16)                         AYED       76 IPWA                      11/77
R1             .225      .025               CUTKOSKY   76 IPWA                      11/77
R1   C         .19       .04                CUTKOSKY   79 IPWA   PI N TO PI N       12/79*
R1             .24       .06                HOEHLER    79 IPWA   PI N TO PI N       12/79*
R1          . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R2       N*3/2(1910) INTO (K SIGMA)/TOTAL                   (P3)
R2  1        (0.008)OR LESS                 FEUERBACH  70 RVUE   PI P TO K+ SIG+     7/70
R2  1      ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68
R2  1      MODEL USED MAY DOUBLE COUNT.

R3       N*3/2(1910) FROM PI N TO K SIGMA                   SQRT(P1*P3)          9/73
R3  9         (.11)                         LANGBEIN   73 IPWA   PI N-K SIG,SOL 1    9/73
R3  9         (.15)                         LANGBEIN   73 IPWA   PI N-K SIG,SOL 2    9/73
R3  2         (.082)TO  .184                DEANS      75 DPWA   PI N TO K SIGMA    11/75
R3  2   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                                    11/75

R4       N*3/2(1910) FROM PI N TO N*3/2(1232) PI            SQRT(P1*P4)         11/77
R4  8        (-.06)                         LONGACRE   77 IPWA   PI N TO 2PI N      11/77

R5       N*3/2(1910) FROM PI N TO N RHO,S=3/2               SQRT(P1*P6)         11/77
R5  8        (-.29)                         LONGACRE   77 IPWA   PI N TO 2PI N      11/77
R5   N       (-.17)                         NOVOSELLE  78 IPWA   PI N TO 2PI N       3/79*
R5   N  EVIDENCE FOR THIS COUPLING IS WEAK, SEE NOVOSELLER 78. THIS                  12/79*
R5   N  COUPLING ASSUMES THE MASS IS NEAR 1820 MEV.                                 12/79*
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              12  N*3/2(1910) PHOTON DECAY AMPL(GEV**-1/2)

     FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
   REVIEW PRECEDING THE BARYON LISTINGS.

A1       N*3/2(1910) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)
A1            .000       .025           DEVENIS2   74 DPWA   PI N PHOTO-PROD     4/75
A1            .010       .012           KNIES      74 DPWA   PI N PHOTO PROD     2/74
A1           -.032       .065           METCALF    74 DPWA   PI N PHOTO-PROD     2/74
A1           -.009       .013           CRAWFORD   75 DPWA   PI N PHOTO-PROD     1/76
A1          (-.031)                     BARBOUR    76 DPWA   PI N PHOTO-PROD     1/76
A1           +.040       .013           AZNAURYAN  77 DPWA   PIO PHTPRD,SOL 1 12/79*
A1           +.039       .012           AZNAURYAN  77 DPWA   PIO PHTPRD,SOL 2 12/79*
A1   5       -.035       .021           BARBOUR    78 DPWA   PI-N PHOTO-PROD     3/79*
A1   5  SUPERSEDES BARBOUR 76.                                                   3/79*
A1          . . . . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

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                                  REFERENCES FOR N*3/2(1910)

DONNACH1 68 PL 26B 161            A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139            DONNACHIE  RAPPORTEUR'S TALK             (GLAS)
    ALSO 68 THESIS                R G KIRSOPP                              (EDIN)

AYED     70 KIEV CONF             R AYED,P BAREYRE, G VILLET            (SACL)IJP
DAVIES   70 NP B21 359            A DAVIES                                 (GLAS)
FEUERBAC 70 NP 16B 85             FEUERBACHER+HOLLADAY               (VANDERBILT)

ALMEHED  72 NP B40 157            +LOVELACE                        (LUND,RUTG)IJP
LANGBEIN 73 NP B53 251            LANGBEIN,WAGNER                     (MUNICH)IJP

DEVENIS2 74 PL 52B 227            DEVENISH,LYTH,RANKIN        (DESY,LANC,BCNN)IJP
KNIES    74 PRD 9 2680            KNIES,MOORHOUSE,OBERLACK          (LBL,GLAS)IJP
METCALF  74 NP B76 253            W J METCALF,R L WALKER                 (CIT)IJP

CRAWFORD 75 NP B97 125            R L CRAWFORD                          (GLAS)IJP
DEANS    75 NP B96 90             +MITCHELL,MONTGOMERY,+        (SFLA,ALABAMA)IJP

AYED     76 CEA-N-1921            AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358           I. M. BARBOUR,R. L. CRAWFORD          (GLAS)IJP
CUTKOSKY 76 PRL 37 645            CUTKOSKY,HENDRICK,KELLY           (CARN+LBL)IJP
    ALSO 76 OXFORD CONF. 49       CUTKOSKY,HENDRICK,CHAO+      (CARN+LBL+BRIS)IJP

AZNAURYA 77  EFI-264(57)-77       +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
LONGACRE 77 NP B122 493           LONGACRE,DOLBEAU                      (SACL)IJP
    ALSO 76 NP B108 365           DOLBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP

BARBOUR  78 NP B141 253           BARBOUR,CRAWFORD,PARSONS                 (GLAS)
NOVOSELL 78 NP B137 509           D. E. NOVOSELLER                  (CAL TECH)IJP
    ALSO 78 NP B137 445           D. E. NOVOSELLER                  (CAL TECH)IJP
CUTKOSKY 79 PRD 20 2839           +FORSYTH,HENDRICK,KELLY           (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                  +KAISER,KOCH,PIETARINEN          /KARLSRUHE IJP

                                  PAPERS NOT REFERRED TO IN DATA CARDS

CARYANN  65 PR 138 B433           CARAYANNOPOULOS,TAUTFEST,WILLMANN     (PURD)
    A PARTIAL WAVE ANALYSIS OF PI+P TO SIGMA+ K+
AYED     70 PL 31B 598            +BAREYRE+VILLET                       (SACLAY)
WINNIK   77 NP B128 66            +TOAFF,REVEL,GOLDBERG,BERNY            (HAIF)I
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Δ(1950) 83 N*3/2(1950, JP=7/2+) I=3/2 F37

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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              83  N*3/2(1950) MASS (MEV)

M          (1920.0)                     DUKE       65 CNTR   PI-P EL + POL       6/68
M          (1950.0)        APPROX       YOKOSAWA   66 CNTR   PI- P DSIG + POL    7/66
M   1      (1975.0)                     BAREYRE    68 RVUE   PHASE-SHIFT ANAL  11/67
M   1              WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M   3      (1546.0)                     DONNACH1   68 RVUE   PHASE-SHIFT ANAL   6/68
M   6      (1931.0)                     AYED       70 IPWA                      1/71
M   6  FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   4      (1935.0)                     DAVIES     70 RVUE   P-S ANAL  SOL A    8/69
M          (1950.0)    (30.0)           KALMUS     70 DPWA   PI+P TO K+ SIG+    1/71
M          (1930.)                      ROYCHOUD   71 DPWA                      3/72
M   7      (1925.)                      ALMEHED    72 IPWA                      2/72
M    2      1920 TO 1951                MEHTANI    72 MPWA   PI+P TO PI+PIOP    9/73
M    K      1930. OR 1925.              LONGACRE   75 IPWA   PI N TO 2PI N     11/75
M    K  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.      11/75
M          (1928.)                      AYED       76 IPWA                     11/77
M           1945.       7.              CUTKOSKY   76 IPWA                     11/77
M    8     (1912.)                      BARBOUR    78 DPWA   PI-N PHOTO-PROD    3/79*
M    C      1950.      20.              CUTKOSKY   79 IPWA   PI N TO PI N      12/79*
M    C  SUPERSEDES CUTKOSKY 76.                                                12/79*
M    L      1913.       8.              HOEHLER    79 IPWA   PI N TO PI N      12/79*
M    H      2425.      60.              HOEHLER    79 IPWA   PI N TO PI N      12/79*
M   LH  HOEHLER79 FINDS A HIGHER MASS F37 RESONANCE, AS WELL AS ONE IN THIS 12/79*
M   LH  MASS REGION. BOTH ARE LISTED HERE, AND LABLED L AND H FOR LOW AND   12/79*
M   LH  HIGH, AWAITING CONFIRMATION OF THE HIGHER MASS STATE.              12/79*
M          . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)
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              83  N*3/2(1950) WIDTH (MEV)

W           (170.0)                     DUKE       65 CNTR                      7/66
W           (200.0)        APPROX       YOKOSAWA   66 CNTR                      7/66
W   1       (180.0)                     BAREYRE    68 RVUE                     11/67
W   3       (221.0)                     DONNACH1   68 RVUE                      6/68
W   6       (197.0)                     AYED       70 IPWA                      1/71
W   4       (221.0)                     DAVIES     70 RVUE   SOL A              8/69
W           (300.0)    (60.0)           KALMUS     70 DPWA   PI+P TO K+ SIG+    1/71
W   7       (200.)                      ALMEHED    72 IPWA                      2/72
W    2      234 TO 269                  MEHTANI    72 MPWA   PI+P TO PI+PIOP    9/73
W    K       235. OR  240.              LONGACRE   75 IPWA   PI N TO 2PI N     11/75
W           (237.)                      AYED       76 IPWA                     11/77
W            305.      40.              CUTKOSKY   76 IPWA                     11/77
W    8      (198.)                      BARBOUR    78 DPWA   PI-N PHOTO-PROD    3/79*
W    C       340.      60.              CUTKOSKY   79 IPWA   PI N TO PI N      12/79*
W    L       224.      10.              HOEHLER    79 IPWA   PI N TO PI N      12/79*
W    H       300.      80.              HOEHLER    79 IPWA   PI N TO PI N      12/79*
W          . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 2.0)
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
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Data Card Listings

For notation, see key at front of Listings.

Baryons

Δ(1950)

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             83  N*3/2(1950) REAL PART OF POLE POSITION (MEV)                  11/75

REE         (1924.)                LONGACRE  75 IPWA    PI N TO 2PI N     11/75
REE         (1915.)                VASAN2    76         FIT AYED 76       11/77
REE          1895.       10.       CUTKOSKY  76 IPWA                      11/77
REE  C      (1892.)                CUTKOSKY  79 IPWA    PI N TO PI N      12/79*
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             83  N*3/2(1950) -2*IMAG PART OF POLE POSITION (MEV)           11/75

IME         (258.)                 LONGACRE  75 IPWA    PI N TO 2PI N     11/75
IME         (220.)                 VASAN2    76         FIT AYED 76       11/77
IME          260.        24.       CUTKOSKY  76 IPWA                      11/77
IME  C      (248.)                 CUTKOSKY  79 IPWA    PI N TO PI N      12/79*
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             83  N*3/2(1950) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          50.         6.        CUTKOSKY  76 IPWA                      11/77
RER  C      (43.)                  CUTKOSKY  79 IPWA    PI N TO PI N      12/79*
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             83  N*3/2(1950) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         -25.         9.        CUTKOSKY  76 IPWA                      11/77
IMR  C      (-24.)                 CUTKOSKY  79 IPWA    PI N TO PI N      12/79*
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             83  N*3/2(1950) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1     N*3/2(1950) INTO PI N                               139+ 938
P2     N*3/2(1950) INTO SIGMA K                           1189+ 493
P3     N*3/2(1950) INTO N*3/2(1232) PI                    1232+ 139
P4     N*3/2(1950) INTO Y*1(1385) K                       1384+ 493
P5     N*3/2(1950) INTO N*3/2(1232) RHO                   1232+ 776
P6     N*3/2(1950) INTO NEUTRON PI+ PI+                    939+ 139+ 139
P7     N*3/2(1950) INTO N*3/2(1232) PI PI (NOT RHO)       1232+ 139+ 139
P8     N*3/2(1950) INTO GAM NUCLEON, HELICITY=1/2           0+ 938
P9     N*3/2(1950) INTO GAM NUCLEON, HELICITY=3/2           0+ 938
P10    N*3/2(1950) INTO N RHO                              938+ 776
P11    N*3/2(1950) INTO N*3/2(1232) PI,F-WAVE             1232+ 139
P12    N*3/2(1950) INTO N*3/2(1232) PI,H-WAVE             1232+ 139
P13    N*3/2(1950) INTO N RHO,S=3/2,F-WAVE                 938+ 776
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             83  N*3/2(1950) BRANCHING RATIOS

R1     N*3/2(1950) INTO (PI N)/TOTAL                       (P1)
R1          (0.41)                 DUKE      65 CNTR    VERY ENERGY DEP   7/66
R1          (0.4)      APPROX      YOKOSAWA  66 CNTR                      7/66
R1   1      (0.57)                 BAREYRE   68 RVUE                      11/67
R1   3      (0.386)                DONNACHI  68 RVUE                      6/68
R1   6      (0.496)                AYED      70 IPWA                      1/71
R1   4      (0.51)                 DAVIES    70 RVUE    SOL A             8/69
R1   7      (0.4)                  ALMEHED   72 IPWA                      2/72
R1           (.41)                 AYED      76 IPWA                      11/77
R1            .396       .010      CUTKOSKY  76 IPWA                      11/77
R1   C        .40        .02       CUTKOSKY  79 IPWA    PI N TO PI N      12/79*
R1   L        .38        .02       HOEHLER   79 IPWA    PI N TO PI N      12/79*
R1   H        .07        .04       HOEHLER   79 IPWA    PI N TO PI N      12/79*
R1     . . . . . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 4.6)
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

R2     N*3/2(1950) INTO (SIGMA K)*(PI N)/TOTAL**2          (P2*P1)
R2          SEEN                   BORREANI  68 HBC     PI+P 1.35-1.68    10/69
R2   1      (0.004)  (0.008)       FEUERBACH 70 RVUE    PI P TO K+ SIG+   7/70
R2   1     ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68
R2   1     MODEL USED MAY DOUBLE COUNT.
R2          0.0081   0.0013        KALMUS    70 DPWA    PI+P TO K+ SIG+   1/71

R3     N*3/2(1950) FROM PI N TO N*3/2(1232) PI         SQRT(P1*P3)
R3   2      .37 TO .48             MEHTANI   72 MPWA    PI+P TO PI+PIOP   9/73
R3   2   MOSTLY F WAVE DECAY                                              9/73

R4     N*3/2(1950) FROM PI N TO SIGMA K                SQRT(P1*P2)        9/73
R4           (.04)                 LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
R4           (.05)                 LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
R4   5       (.022)TO  .040        DEANS     75 DPWA    PI N TO K SIGMA   11/75
R4   5   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                         11/75
R4   5   DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF  1/78
R4   5   WINNIK77 AROUND 1920 MEV.                                        1/78

R5     N*3/2(1950) FROM PI N TO N*3/2(1232) PI,F-WAVE  SQRT(P1*P11)       11/75
R5   K       (-.25)OR  -.32        LONGACRE  75 IPWA    PI N TO 2PI N     11/75
R5   M        (.21)                NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79*
R5   M   BW FIT TO LONGACRE 75 IPWA, PHASE IS NEAR -60 DEGREES.           3/79*
R5   N        (.38)                NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79*
R5   N   BW FIT TO NOVOSELLER 78 IPWA, PHASE IS NEAR -60 DEGREES.         3/79*

R6     N*3/2(1950) FROM PI N TO N RHO,S=3/2,F-WAVE     SQRT(P1*P13)       11/75
R6   K       (.18)OR   -.24        LONGACRE  75 IPWA    PI N TO 2PI N     11/75
R6   P        (.24)                NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79*
R6   P   BW FIT TO LONGACRE 75 IPWA, PHASE IS NEAR 120 DEGREES.           3/79*
R6   Q        (.43)                NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79*
R6   Q   BW FIT TO NOVOSELLER 78 IPWA, PHASE IS NEAR 120 DEGREES.         3/79*

       MORE INFORMATION ON INELASTIC DECAY MODES OF BUMPS, SEEN IN PRODUCTION
       EXPERIMENTS AROUND 1950 MEV, MAY BE FOUND IN THE NEXT ENTRY
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             83  N*3/2(1950) PHOTON DECAY AMPL(GEV**-1/2)

       FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
       REVIEW PRECEDING THE BARYON LISTINGS.

A1     N*3/2(1950) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)
A1          -.088        .025      DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A1          -.070        .012      KNIES     74 DPWA    PI N PHOTO PROD   2/74
A1          -.059        .029      METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A1         (-.080)                 MOORHOUS  74 DPWA    PI N PHOTO-PROD.  2/74
A1          -.053        .005      CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A1         (-.076)                 BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A1          -.078        .008      AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1  12/79*
A1          -.132        .015      AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2  12/79*
A1   8      -.058        .013      BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A1   8   SUPERSEDES BARBOUR 76.                                           3/79*
A1     . . . . . . . . . .
A1   AVERAGE MEANINGLESS (SCALE FACTOR = 2.4)

A2     N*3/2(1950) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)
A2          -.080        .021      DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A2          -.078        .010      KNIES     74 DPWA    PI N PHOTO PROD   2/74
A2          -.093        .024      METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A2         (-.180)                 MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A2          -.038        .014      CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A2         (-.065)                 BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A2          -.160        .016      AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1  12/79*
A2          -.169        .015      AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2  12/79*
A2   8      -.075        .020      BARBOUR   78 DPWA    PI-N PHOTO-PROD   3/79*
A2     . . . . . . . . . .
A2   AVERAGE MEANINGLESS (SCALE FACTOR = 3.2)

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                         REFERENCES FOR N*3/2(1950)

DUKE      65 PRL 15 468          +JONES,KEMP,MURPHY,PRENTICE, +   (RHEL,CXF)IJP
YOKOSAWA 66 PRL 16 714           +SUWA, HILL, ESTERLING, BOOTH    (ANL,CHIC)IJP

BAREYRE   68 PR 165 1731         P BAREYRE, C BRICMAN, G VILLET        (SACLAY)IJP
BORREANI  68 UCRL 18350            BORREANI,KALMUS                          (LRL)
DONNACHI  68 PL 26B 161          A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO  68 VIENNA 139          DONNACHIE  RAPPORTEUR'S TALK              (GLAS)
    ALSO  68 THESIS              R G KIRSOPP                               (EDIN)

AYED      70 KIEV CONF           R AYED,P BAREYRE, G VILLET             (SACL)IJP
DAVIES    70 NP B21 359          A DAVIES                                  (GLAS)
FEUERBAC  70 NP 16B 85           FEUERBACHER+HOLLADAY                (VANDERBILT)
KALMUS    70 PR D2 1824          G KALMUS, G BORREANI, J LOUIE              (LRL)

ROYCHOUD  71 NP B27 125          R K ROYCHOUDHURY,B H BRANSDEN          (DURH)IJP

ALMEHED   72 NP B40 157          +LOVELACE                        (LUND,RUTG)IJP
MEHTANI   72 PRL 29 1634         +FUNG, KERNAN, SCHALK, +            (UCR +LBL)
LANGBEIN  73 NP B53 251          LANGBEIN,WAGNER                      (MUNICH)IJP

DEVENIS2  74 PL 52B 227          DEVENISH,LYTH,RANKIN       (DESY,LANC,BONN)IJP
KNIES     74 PRD 9 2680          KNIES,MOORHOUSE,OBERLACK        (LBL,GLAS)IJP
METCALF   74 NP B76 253          W J METCALF,R L WALKER                (CIT)IJP
MOORHOUS  74 PRD 9 1             MOORHOUSE,OBERLACK,ROSENFELD   (GLAS+LBL)IJP

CRAWFORD  75 NP B97 125          R L CRAWFORD                          (GLAS)IJP
DEANS     75 NP B96 90           +MITCHELL,MONTGOMERY,+      (SFLA,ALABAMA)IJP
LONGACRE  75 PL 55B 415          +ROSENFELD,LASINSKI,SMADJA+     (LBL,SLAC)IJP
    ALSO  78 PRD 17 1795         LONGACRE,LASINSKI,ROSENFELD+      (LBL,SLAC)

AYED      76 CEA-N-1921          AYED (THESIS)                         (SACL)IJP
BARBOUR   76 NP B111 358         I. M. BARBOUR,R. L. CRAWFORD          (GLAS)IJP
CUTKOSKY  76 PRL 37 645          CUTKOSKY,HENDRICK,KELLY           (CARN+LBL)IJP
    ALSO  76 OXFORD CONF. 49     CUTKOSKY,HENDRICK,CHAO+      (CARN+LBL+BRIS)IJP
VASAN2    76 NP B106 526         S. S. VASAN                           (CARN)IJP

AZNAURYA  77  EFI-264(57)-77     +AKOPOV,BAGDASARYAN (YEREVAN PHYSICS INST.)IJP
BARBOUR   78 NP B141 253         BARBOUR,CRAWFORD,PARSONS                 (GLAS)
NOVOSELL  78 NP B137 509         D. E. NOVOSELLER                   (CAL TECH)IJP
    ALSO  78 NP B137 445         D. E. NOVOSELLER                   (CAL TECH)IJP

CUTKOSKY  79 PRD 20 2839         +FORSYTH,HENDRICK,KELLY           (CARN+LBL)IJP
HOEHLER   79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                 +KAISER,KOCH,PIETARINEN          /KARLSRUHE IJP

                         PAPERS NOT REFERRED TO IN DATA CARDS

HOHLER    63 NP 48 470           G HOHLER, G EBEL                  (KARLSRUHE) I
LAYSON    63 NC 27 724           W M LAYSON                            (CERN) IJ
AUVIL     64 NC 33 473           P AUVIL, C LOVELACE                  (LOIC)IJP
HELLAND   64 PR 134 B1062        +DEVLIN,HAGGE,LONGO,MOYER,WOOD        (LRL) IJ
HOHLER    64 PL 12 149           G HOHLER, J GIESECKE              (KARLSRUHE) I
HOLLADAY  65 PR 139 B1348        W G HOLLADAY                        (VANDERBILT)
JOHNSON   67 UCRL-17683 THESIS   C H JOHNSON                                (LRL)
DONNACHI  69 NP 10B 433          A DONNACHIE, R KIRSOPP               (GLAS+EDIN)
AYED      70 PL 31B 598          +BAREYRE+VILLET                        (SACLAY)
AYED      74 PRIVATE COMMCTN.    AYED,BAREYRE                           (SACL)IJP
    ALSO  73 AIX CONFERENCE      AYED,BAREYRE                           (SACL)IJP
WINNIK    77 NP B128 66          +TOAFF,REVEL,GOLDBERG,BERNY              (HAIF)I

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1950 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

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             70  N*3/2(1950, JP=     ) I=3/2    PRODUCTION EXPERIMENTS

             SEE THE MINI-REVIEW PRECEDING THE N AND DELTA LISTINGS
             FOR A DISCUSSION OF PRODUCTION EXPERIMENTS
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             70  N*3/2(1950) MASS (MEV)  (PROD. EXP.)

M           (1922.0)       APPROX      COOL      56 CNTR    PI+ P TOTAL       7/66
M           (1912.0)    (15.0)         BRISSON   61 CNTR    PI+ P TOTAL       7/66
M           (1900.0)     (9.0)         DEVLIN    65 CNTR    PI+ P TOTAL
M    N      (2080.0)    (12.0)         YOON      67 HBC  +  3 BEV/C PI-P      8/67
M    N     THIS BUMP IS NOT SEEN BY CHUNG 68 AT 3.2 GEV/C
M           (1860.0)                   COLTON    72 HBC  ++ PP TO PI+PN 7GEV  1/73
M           (1895.)     (15.)          COLLEY    74 HBC  ++ K+P TO K+PPI+PI-  10/74
M           (1890.)      5. TO 10.     BRAUN2    75  BC     PBAR P AND D,5.7 11/75
M    C      (1881.)      (6.)          CHUNG     75 HBC  ++ PI+ P AND K+ P    1/76
M    C     MOST PROBABLE JP ASSIGNMENT IS 7/2+.                              1/76
M           (1880.)     (10.)          GAIDOS    75 HBC  ++ PI+P TO N* 2PI    1/76
M    B   540(1871.)     (22.)          ZEMANY    78 HBC  ++ PI+P  10.3 GEV/C  3/79*
M    B     BEST SIGNAL IS SEEN IN THE P PI+ SPECTRUM FROM THE                3/79*
M    B     P PI+ PI+ PI- FINAL STATE                                          3/79*
M    O   600 1849. TO 1893.            ZEMANY    78 HBC  ++ PI+P  10.3 GEV/C  3/79*
M    O     FROM OTHER N PI, N PI PI AND SIGMA K CHANNELS                     3/79*
M        150(1880.)     (30.)          APELDOORN 79 HBC  ++ PBAR P 7.2 GEV/C 12/79*
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             70  N*3/2(1950) WIDTH (MEV)  (PROD. EXP.)

W            (2#6.0)    (39.0)         DEVLIN    65 CNTR
W             (40.0)    (20.0)         YOON      67 HBC  +                    8/67
W            (180.0)                   COLTON    72 HBC  ++ PP TO PI+PN 7GEV  1/73
W            (230.)     (50.)          COLLEY    74 HBC  ++ K+P TO K+PPI+PI-  10/74
W            (120.)      10.  TO 20.   BRAUN2    75  BC     PBAR P AND D,5.7 11/75
W    C       (219.)     (23.)          CHUNG     75 HBC  ++ PI+ P AND K+ P    1/76
W            (180.)     (30.)          GAIDOS    75 HBC  ++ PI+P TO N* 2PI    1/76
W    B   540 (205.)     (43.)          ZEMANY    78 HBC  ++ PI+P  10.3 GEV/C  3/79*
W    O   600  114.  TO  273.           ZEMANY    78 HBC  ++ PI+P  10.3 GEV/C  3/79*
W        150 (270.)     (70.)          APELDOORN 79 HBC  ++ PBAR P 7.2 GEV/C 12/79*
           SEE THE NOTES ACCOMPANYING THE MASSES QUOTED ABOVE
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Baryons
Δ(1950), Δ(1960)

Data Card Listings
For notation, see key at front of Listings.

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                 70  N*3/2(1950) PARTIAL DECAY MODES (PROD. EXP.)

                                                            DECAY MASSES
P1     N*3/2(1950) INTO PI N                                 139+ 938
P2     N*3/2(1950) INTO SIGMA K                             1189+ 493
P3     N*3/2(1950) INTO N*3/2(1232) PI                      1232+ 139
P4     N*3/2(1950) INTO Y*1(1385) K                         1384+ 493
P5     N*3/2(1950) INTO N*3/2(1232) RHO                     1232+ 776
P6     N*3/2(1950) INTO NEUTRON PI+ PI+                      939+ 139+ 139
P7     N*3/2(1950) INTO N*3/2(1232) PI PI (NOT RHO)         1232+ 139+ 139
P8     N*3/2(1950) INTO PROTON PI+ PIO                       938+ 139+ 139
P9     N*3/2(1950) INTO PI PI N                              139+ 139+ 938

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                 70  N*3/2(1950) BRANCHING RATIOS (PROD. EXP.)

R1     N*3/2(1950) INTO (PI N)/TOTAL                        (P1)
R1           (0.57)    (0.12)       DEVLIN    65 CNTR
R1           (0.48)    (0.15)       ZEMANY    78 HBC  ++ PI+P  10.3 GEV/C  1/78

R2     N*3/2(1950) INTO (SIGMA K)/(PI N)                    (P2)/(P1)
R2            0.059     0.024       CHINOWSKY 68 HBC  ++ PP TO P SIG K    11/68

R3     N*3/2(1950) INTO N*3/2(1232) PI PI (NOT RHO)         (P7)
R3            SEEN                  CHINOWSKY 68 HBC  ++ PP TO (P 3PI) N  11/68
R3            SEEN                  BOGGILD   70  HBC    PP TO N3PI(NTRL)  6/70

R4     N 3/2(1950) INTO (PI N)/(N*3/2(1232) PI)             (P1)/(P3)
R4           (0.55) OR LESS         LEE       67 HBC     PI-P 3.63 BEV/C  11/67

R5     N*3/2(1950) INTO ((PI N)*(NEUTRON PI+ PI+))/TOTAL**2
R5                                                          (P1*P6)
R5            0.05      0.013       GALLOWAY  68 RVUE ++ PI+P TO N 2PI+    6/68

R6     N*3/2(1950) INTO (Y*1(1385) K)/(PI N)                (P4)/(P1)
R6            0.035     0.015       CHINOWSKY 68 HBC  ++ PP TO P LAM K PI 11/68

R7     N*3/2(1950) INTO (N*3/2(1232) RHO)/(PI N)            (P5)/(P1)
R7           (0.45)     APPROX      CHINOWSKY 68 HBC  ++ PP TO (P 3PI) N  11/68
R7     THIS INCLUDES CORRECTION FOR UNSEEN DECAY (ISPIN FACTOR 5/3).

R8     N*3/2(1950) INTO (N*3/2(1232) RHO)/TOTAL             (P5)
R8            SEEN                  YOON      67 HBC  +                    8/67
R8            NOT SEEN              BOGGILD   70  HBC    PP TO N3PI(NTRL)  6/70

R9     N*3/2(1950) INTO (PROTON PI+ PIO)/TOTAL              (P8)
R9           (0.26)    (0.07)       ZEMANY    78 HBC  ++ PI+P  10.3 GEV/C  1/78

R10    N*3/2(1950) INTO (NEUTRON PI+ PI+)/TOTAL             (P6)
R10          (0.24)    (0.07)       ZEMANY    78 HBC  ++ PI+P  10.3 GEV/C  1/78

R11    N*3/2(1950) INTO (SIGMA K)/TOTAL                     (P2)
R11          (0.03)    (0.01)       ZEMANY    78 HBC  ++ PI+P  10.3 GEV/C  3/79*

R12    N*3/2(1950) INTO (PI PI N)/(PI N + PI PI N)          (P9)/(P1+P9)
R12 D        (0.35)    (0.08)       GAIDOS    75 HBC  ++ PI+P TO N* 2PI    1/78
R12 D   ASSUMING (PI PI N) IS ALL N*3/2(1232) PI, WHICH AGREES WITH DATA   1/78
R12 R        (0.30)    (0.07)       GAIDOS    75 HBC  ++ PI+P TO N* 2PI    1/78
R12 R   ASSUMING (PI PI N) IS ALL RHO PI                                   1/78

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                              REFERENCES FOR N*3/2(1950) (PROD. EXP.)

COOL      56 PR 103 1082      R COOL, O PICCIONI, D CLARK             (BNL) I
BRISSON   61 NC 19 210        +DETOEUF,FALK-VAIRANT,VAN ROSSUM,+ (SACLAY) I
DEVLIN    65 PRL 14 1031      T J DEVLIN,J SOLOMON,G BERTSCH  (PRINCETON) I
LEE       67 PR 159 1156      +MOEBS,ROE,SINCLAIR,VANDER VELDE       (MICH)
YOON      67 PL 24B 307       +BERENYI,KEY,PRENTICE, +        (TORONTO,WISC)

CHINOWSK  68 PR 171 1421      CHINOWSKY,CONDON,KINSEY,KLEIN,+  (LRL,SLAC)
CHUNG     68 PR 165 1491      S U CHUNG,DAHL,KIRZ,MILLER              (LRL)
GALLOWAY  68 PL 26B 334       K F GALLOWAY                       (INDIANA) I

BOGGILD   70 NP B16 503       +KOREA-AHO+JACOBSEN+ (BOHR+ HELS+OSLO+STOH)
COLTON    72 PR D6 95         E COLTON, A KIRSCHBAUM                  (LBL)
COLLEY    74 NP B69 205       COLLEY,HUQ,JOBES,KINSON,MILNE,+ (BIRM+GLAS)I

BRAUN2    75 NP B95 503       +GERBER,MAURER,MICHALON,SCHIBY+ STBRB,LPNP I
CHUNG     75 PL 57B 384       +PROTOPOPESCU,EISNER+    (BNL+CASE+LBL+UCSC)IJP
   ALSO   75 PRD 12 693       CHUNG,PROTOPOPESCU,EISNER+  (BNL+CASE+UCSC)IJP
GAIDOS    75 PRD 12 2565      GAIDOS,MILLER                          (PURD)IJP

ZEMANY    78 NP B137 365      +BEAUFAYS,GODDARD,KEY+       (TNTO+PURD+BNL)IJP
   ALSO   78 NP B138 265      GODDARD,KEY,GORDON,LAI              (TNTO+BNL)
   ALSO   78 PRD 17 2888      KENNEDY,ZEMANY,BEAUFAYS,KEY,LUSTE+    (TNTO)
APELDOOR  79 NP B156 111      VAN APELDOORN,HARTING,HOLTHUIZEN+     (AMST)

                              PAPERS NOT REFERRED TO IN DATA CARDS

DEUTSCHM  75 NP B99 397       DEUTSCHMANN+(AACH+BONN+BERL+CERN+CRAC+HEID)
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Δ(1960) 117 N*3/2(1960, JP=3/2+) I=3/2 **P'''_{33}**

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                   EARLY ANALYSES FOUND EVIDENCE FOR A P33 RESONANCE NEAR
                   2160 MEV, THERE MAY HAVE BEEN CONFUSION WITH OTHER
                   RESONANCES IN THAT REGION (SEE LISTING FOR N*3/2(2160)).
                   RECENT ANALYSES AGREE THAT THE MASS IS CLOSER TO
                   1960 MEV.

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                   117  N*3/2(1960) MASS  (MEV)

M   3      (2160.)                     KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69
M          (2120.)                     ROYCHOUD  71 DPWA                     3/72
M   7      (2150.)                     ALMEHED   72 IPWA                     2/72
M    1     (1980.)                     LANGBEIN  73 IPWA   PI N-K SIG,SOL 1  9/73
M    1  NOT SEEN IN SOLUTION 2 OF LANGBEIN73                                 9/73
M    1  DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF      1/78
M    1  WINNIK77 AROUND 1920 MEV.                                            1/78
M           1960.       80.            CUTKOSKY  79 IPWA   PI N TO PI N     12/79*
M           1868.       10.            HOEHLER   79 IPWA   PI N TO PI N     12/79*
M           . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                   117  N*3/2(1960) WIDTH  (MEV)

W   3      (260.)                      KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69
W   7      (200.)                      ALMEHED   72 IPWA                     2/72
W    1     (190.)                      LANGBEIN  73 IPWA   PI N-K SIG,SOL 1  9/73
W           300.       100.            CUTKOSKY  79 IPWA   PI N TO PI N     12/79*
W           220.        80.            HOEHLER   79 IPWA   PI N TO PI N     12/79*
W           . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                   117  N*3/2(1960) REAL PART OF POLE POSITION  (MEV)

REE        (1933.)                     CUTKOSKY  79 IPWA   PI N TO PI N     12/79*

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                   117  N*3/2(1960) -2*IMAG PART OF POLE POSITION  (MEV)

IME        (280.)                      CUTKOSKY  79 IPWA   PI N TO PI N     12/79*

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                   117  N*3/2(1960) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER        (-10.)                      CUTKOSKY  79 IPWA   PI N TO PI N     12/79*

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                   117  N*3/2(1960) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR        (-27.)                      CUTKOSKY  79 IPWA   PI N TO PI N     12/79*

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                   117  N*3/2(1960) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     N*3/2(1960) INTO PI N                              139+ 938
P2     N*3/2(1960) INTO K SIGMA                           493+1189

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                   117  N*3/2(1960) BRANCHING RATIOS

R1     N*3/2(1960) INTO (PI N)/TOTAL                       (P1)             12/79*
R1  3       (.25)                      KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69
R1  7      (0.3)                       ALMEHED   72 IPWA                     2/72
R1           .17       .04             CUTKOSKY  79 IPWA   PI N TO PI N     12/79*
R1           .14       .04             HOEHLER   79 IPWA   PI N TO PI N     12/79*
R1          . . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R2     N*3/2(1960) FROM PI N TO K SIGMA                    SQRT(P1*P2)      12/79*
R2   1      (.08)                      LANGBEIN  73 IPWA   PI N-K SIG,SOL 1  9/73
R2  5       (.048)TO  .120             DEANS     75 DPWA   PI N TO K SIGMA  11/75
R2  5   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                            11/75

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                              REFERENCES FOR N*3/2(1960)

KIRSOPP   68 THESIS           R G KIRSOPP                            (EDIN)
ROYCHOUD  71 NP B27 125       R K ROYCHOUDHURY,B H BRANSDEN       (DURH)IJP

ALMEHED   72 NP B40 157       +LOVELACE                        (LUND,RUTG)IJP
LANGBEIN  73 NP B53 251       LANGBEIN,WAGNER                      (MUNICH)IJP
DEANS     75 NP B96 90        +MITCHELL,MONTGOMERY,+          (SFLA,ALABAMA)IJP

CUTKOSKY  79 PRD 20 2839      +FORSYTH,HENDRICK,KELLY             (CARN+LBL)IJP
HOEHLER   79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN             /KARLSRUHE IJP
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Δ(1960) 13 N*3/2(1960, JP=5/2-) I=3/2 **D_{35}**

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                   13  N*3/2(1960) MASS (MEV)

M   3      (1954.0)                    DONNACH1  68 RVUE   PHASE-SHIFT ANAL  6/68
M   3      (1970.)                     KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69
M   X      (1950.0)       APPROX       LEA       69 CNTR   PI-P ELASTIC      8/69
M   X   SEE ALSO APLIN 70
M   3   WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1   10/69
M   7      (2200.)                     ALMEHED   72 IPWA                     2/72
M    1     (1960.)                     LANGBEIN  73 IPWA   PI N-K SIG,SOL 2  9/73
M    1  NOT SEEN IN SOLUTION 1 OF LANGBEIN73                                 9/73
M    1  DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA CF      1/78
M    1  WINNIK77 AROUND 1920 MEV.                                            1/78
M          (1894.)                     AYED      76 IPWA                    11/77
M           1925.       20.            CUTKOSKY  76 IPWA                    11/77
M   4      (2024.)                     BARBOUR   78 DPWA   PI-N PHOTO-PROD   3/79*
M   C       1930.       20.            CUTKOSKY  79 IPWA   PI N TO PI N     12/79*
M   C   SUPERSEDES CUTKOSKY 76.                                             12/79*
M   L       1901.       15.            HOEHLER   79 IPWA   PI N TO PI N     12/79*
M   H       2305.       26.            HOEHLER   79 IPWA   PI N TO PI N     12/79*
M   LH  HOEHLER79 FINDS A HIGHER MASS D35 RESONANCE, AS WELL AS ONE IN THIS 12/79*
M   LH  MASS REGION. BOTH ARE LISTED HERE, AND LABLED L AND H FOR LOW AND   12/79*
M   LH  HIGH, AWAITING CONFIRMATION OF THE HIGHER MASS STATE.               12/79*
M           . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 8.1)

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                   13  N*3/2(1960) WIDTH (MEV)

W   3      (311.00)                    DONNACH1  68 RVUE                     8/69
W   3      (400.)                      KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69
W   7      (600.)                      ALMEHED   72 IPWA                     2/72
W    1     (150.)                      LANGBEIN  73 IPWA   PI N-K SIG,SOL 2  9/73
W          (121.)                      AYED      76 IPWA                    11/77
W           350.       100.            CUTKOSKY  76 IPWA                    11/77
W   4      (462.)                      BARBOUR   78 DPWA   PI-N PHOTO-PROD   3/79*
W   C       280.        90.            CUTKOSKY  79 IPWA   PI N TO PI N     12/79*
W   L       195.        60.            HOEHLER   79 IPWA   PI N TO PI N     12/79*
W   H       300.        70.            HOEHLER   79 IPWA   PI N TO PI N     12/79*
W           . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
          SEE THE NOTES ACCOMPANYING MASSES QUOTED

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Data Card Listings

For notation, see key at front of Listings.

Baryons

Δ(1960), Δ(2160)

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                    13  N*3/2(1960) REAL PART OF POLE POSITION (MEV)

REE        1860.      15.              CUTKOSKY  76 IPWA                    11/77
REE  C    (19C8.)                      CUTKOSKY  79 IPWA    PI N TO PI N    12/79*

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                    13  N*3/2(1960) -2*IMAG PART OF POLE POSITION (MEV)

IME         276.      40.              CUTKOSKY  76 IPWA                    11/77
IME  C     (226.)                      CUTKOSKY  79 IPWA    PI N TO PI N    12/79*

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                    13  N*3/2(1960) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          12.       3.              CUTKOSKY  76 IPWA                    11/77
RER  C      (13.)                      CUTKOSKY  79 IPWA    PI N TO PI N    12/79*

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                    13  N*3/2(1960) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         -15.       4.              CUTKOSKY  76 IPWA                    11/77
IMR  C      (2.)                       CUTKOSKY  79 IPWA    PI N TO PI N    12/79*

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                    13  N*3/2(1960) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N*3/2(1960) INTO PI N                            139+ 938
P2      N*3/2(1960) INTO K SIGMA                         493+1189

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                    13  N*3/2(1960) BRANCHING RATIOS

R1      N*3/2(1960) INTO (PI N)/ TOTAL                  (P1)
R1  3          (.154)                  DONNACH1  68 RVUE    PHASE SHIFT ANA. 10/69
R1  3          (.12)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1  7         (0.25)                   ALMEHED   72 IPWA                      2/72
R1             (.08)                   AYED      76 IPWA                     11/77
R1              .133     .013          CUTKOSKY  76 IPWA                     11/77
R1   C          .12      .03           CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
R1   L          .04      .03           HOEHLER   79 IPWA    PI N TO PI N     12/79*
R1   H          .04      .02           HOEHLER   79 IPWA    PI N TO PI N     12/79*
R1            . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 2.6)

R2      N*3/2(1960) INTO (K SIGMA)/TOTAL                (P2)
R2  1       (0.013)  (0.01)           FEUERBACH 70 RVUE    PI P TO K+ SIG+    7/70
R2  1       ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68
R2  1       MODEL USED MAY DOUBLE COUNT.

R3 ·    N*3/2(1960) FROM PI N TO K SIGMA               SQRT(P1*P2)         9/73
R3   1         (.08)                   LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
R3  2          (.018)TO  .035          DEANS     75 DPWA    PI N TO K SIGMA  11/75
R3  2   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                             11/75

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                    13  N*3/2(1960) PHOTON DECAY AMPL(GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*3/2(1960) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)              1/76
A1             +.003     .016          CRAWFORD  75 DPWA    PI N PHOTO-PROD  1/76
A1            (-.C85)                  BARBOUR   76 DPWA    PI N PHOTO-PROD  1/76
A1   4         -.C62     .064          BARBOUR   78 DPWA    PI-N PHOTO-PROD  3/79*
A1   4  SUPERSEDES BARBOUR 76.                                               3/79*
A1            . . . . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

A2      N*3/2(1960) INTO GAM NUCLEON, HELICIYT=3/2 (GEV**-1/2)              1/76
A2             -.010     .032          CRAWFORD  75 DPWA    PI N PHOTO-PROD  1/76
A2            (+.066)                  BARBOUR   76 DPWA    PI N PHOTO-PROD  1/76
A2   4         +.019     .054          BARBOUR   78 DPWA    PI-N PHOTO-PROD  3/79*
A2            . . . . . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                             REFERENCES FOR N*3/2(1960)

DONNACH1 68 PL 26B 161          A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
KIRSOPP  68 THESIS              R G KIRSOPP                            (EDIN)

LEA      69 PL 29B 584          LEA,OADES,WARD,COWAN,+  (RHEL,BRISTOL,DARE)
FEUERBAC 70 NP 16B 85           FEUERBACHER+HOLLADAY          (VANDERBILT)
ALMEHED  72 NP B40 157          +LOVELACE                     (LUND,RUTG)IJP

LANGBEIN 73 NP B53 251          LANGBEIN,WAGNER                   (MUNICH)IJP

CRAWFORD 75 NP B97 125          R L CRAWFORD                        (GLAS)IJP
DEANS    75 NP B96 90           +MITCHELL,MCNTGOMERY,+      (SFLA,ALABAMA)IJP

AYED     76 CEA-N-1921          AYED (THESIS)                       (SACL)IJP
BARBOUR  76 NP B111 358         I. M. BARBOUR,R. L. CRAWFORD        (GLAS)IJP
CUTKOSKY 76 PRL 37 645          CUTKOSKY,HENDRICK,KELLY         (CARN+LBL)IJP
    ALSO 76 OXFORD CONF. 49     CUTKOSKY,HENDRICK,CHAO+    (CARN+LBL+BRIS)IJP

BARBCUR  78 NP B141 253         BARBOUR,CRAWFORD,PARSONS            (GLAS)
CUTKOSKY 79 PRD 20 2839         +FORSYTH,HENDRICK,KELLY         (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN          /KARLSRUHE IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS

DCNNACHI 69 NP 10B 433          A DONNACHIE, R KIRSOPP           (GLAS+EDIN)
AYED     70 PL 31B 598          +BAREYRE+VILLET                     (SACLAY)
APLIN    71 NP B32 253          +COWAN,GIBSCN,GILMORE++      (RHEL,BRISTOL)
WINNIK   77 NP B128 66          +TOAFF,REVEL,GOLDBERG,BERNY          (HAIF)I

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Δ(2160)

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                 9  N*3/2(2160,          ) I=3/2

                        EARLY ANALYSES FOUND EVIDENCE FOR A RESONANCE
                        NEAR THIS MASS IN THE P33 PARTIAL WAVE.  THESE
                        RESULTS ARE NOW INCLUDED WITH THE LISTING FOR
                        N*3/2(1960, JP=3/2+).  IN ADDITION, ROYCHOUDHURY 71
                        FIND POSSIBLE EVIDENCE FOR P31, D33, AND D35
                        RESONANCES IN THIS MASS REGION.  IN A SIMILAR ANALYSIS
                        BRANSDEN 71 FOUND SOME EVIDENCE FOR S31, D33, AND D35
      RESONANCES IN THIS REGION. VON SCHLIPPE 72 SUGGESTS A G39. A PRONCUNCED
      SHARP DIP IS OBSERVED IN PI+ P BACKWARD SCATTERING AT 2200 MEV BY
      REY 74.  DUAL INTERFERENCE MODEL ANALYSIS OF MA 75 FINDS SIGNAL FOR
      P33, P31, AND D35, BUT NOT FOR G39.  AYED 76 FINDS A G39 RESONANCE
      IN THIS MASS REGION, CUTKOSKY 79 AND HOEHLER 79 FIND A G37 RESONANCE,
      HENDRY 78 FINDS BOTH A G37 AND A G39 RESONANCE.

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                 9  N*3/2(2160) MASS  (MEV)

M   4     (2196.)    (46.)    (41.)   REY       74 MPWA ++ PI+ P 180 DEG CS 10/74
M   4   BAKER 74 AND REY 74 FIND NEGATIVE PARITY (SPIN UNDETERMINED).
M   2     (2170.)                     AYED      76 IPWA                     11/77
M   2   AYED 76 RESULT IS A G39 RESONANCE.                                  11/77
M    9     2200.     100.             HENDRY    78 MPWA    PI N TO PI N     12/79*
M    9  HENDRY 78 RESULT LABELED 9 IS A G39 RESONANCE.                      12/79*
M    7     2280.      80.             HENDRY    78 MPWA    PI N TO PI N     12/79*
M    7  HENDRY 78 RESULT LABELED 7 IS A G37 RESONANCE.                      12/79*
M    C    (2200.)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
M    C  CUTKOSKY 79 RESULT IS A G37 RESONANCE.                              12/79*
M    1     2215.      60.             HOEHLER   79 IPWA    PI N TO PI N     12/79*
M    1  HOEHLER 79 RESULT IS A G37 RESONANCE.                               12/79*

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                 9  N*3/2(2160) WIDTH (MEV)

W   4     (302.)   (143.)             REY       74 MPWA ++ PI+ P 180 DEG CS 10/74
W   2     (205.)                      AYED      76 IPWA                     11/77
W    9     450.     200.              HENDRY    78 MPWA    PI N TO PI N     12/79*
W    7     400.     150.              HENDRY    78 MPWA    PI N TO PI N     12/79*
W    C    (350.)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
W    1     400.     100.              HOEHLER   79 IPWA    PI N TO PI N     12/79*
       SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                 9  N*3/2(2160) REAL PART OF PCLE POSITION  (MEV)

REE  C    (2054.)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                 9  N*3/2(2160) -2*IMAG PART OF POLE POSITION  (MEV)

IME  C    (294.)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                 9  N*3/2(2160) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER  C      (2.)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                 9  N*3/2(2160) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR  C     (-7.)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79*

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                 9  N*3/2(2160) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N*3/2(2160) INTO PI N                            139+ 938
P2      N*3/2(2160) INTO K SIGMA                         493+1189

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                 9  N*3/2(2160) BRANCHING RATIOS

R1      N*3/2(2160) INTO (PI N)/TOTAL                   (P1)
R1  4    REY74 FINDS (J+1/2)X=.81+/-(.54/.39)                               10/74
R1  2          (.04)                  AYED      76 IPWA                     11/77
R1   9          .10      .03          HENDRY    78 MPWA    PI N TO PI N     12/79*
R1   7          .09      .02          HENDRY    78 MPWA    PI N TO PI N     12/79*
R1   C         (.05)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79*
R1   1          .05      .02          HOEHLER   79 IPWA    PI N TO PI N     12/79*

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                             REFERENCES FOR N*3/2(2160)

REY      74 PRL 32 908          REY,LENNOX,POIRIER,PRETZL        (NDAM+MPIM)IP
    ALSO 74 PRL 33 250          REY,LENNOX,POIRIER,PRETZL        (NDAM+MPIM)IP
    ALSO 75 PRD 11 1777         LENNOX,POIRIER,REY,SANDER+  (NDAM+FNAL+ANL)IP
AYED     76 CEA-N-1921          AYED (THESIS)                       (SACL)IJP

HENDRY   78 PRL 41 222          ARCHIBALD W. HENDRY              (IND+LBL)IJP
CUTKOSKY 79 PRD 20 2839         +FORSYTH,HENDRICK,KELLY         (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN          /KARLSRUHE IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS

DCNNACHI 69 NP 10B 433          A DONNACHIE,R KIRSOPP            (GLAS+EDIN)
BRANSDEN 71 NP B26 511          ,OGDEN                              (DURH)IJP
    ALSO 70 NP B16 461          ROYCHOUDHURY,PERRIN,BRANSDEN        (DURH)IJP
ROYCHOUD 71 NP B27 125          R K ROYCHOUDHURY,B H BRANSDEN       (DURH)IJP
VON SCHL 72 LNC 4 767           VON SCHLIPPE                        (LOWC)IJP
BAKER    74 PRL 32 251          BAKER,EARTLY,PRETAL,PRUSS,+ (FNAL,ANL,NDAM)P
MA       75 PRD 11 1832         MA,SHAW                        (UCSB,SLAC)IJP
WINNIK   77 NP B128 66          +TOAFF,REVEL,GOLDBERG,BERNY          (HAIF)I

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Baryons
Δ(2300), Δ(2420), Δ(2500)

Data Card Listings
For notation, see key at front of Listings.

Δ(2300) 123 N*3/2(2300, JP=9/2+) I=3/2 **H_{39}**

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                123  N*3/2(2300) MASS  (MEV)

M         2217.      80.             HOEHLER   79 IPWA    PI N TO PI N    12/79*

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                123  N*3/2(2300) WIDTH  (MEV)

W          300.     100.             HOEHLER   79 IPWA    PI N TO PI N    12/79*

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                123  N*3/2(2300) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     N*3/2(2300) INTO PI N                            139+ 938

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                123  N*3/2(2300) BRANCHING RATIOS

R1     N*3/2(2300) INTO (PI N)/TOTAL                    (P1)              12/79*
R1            .03       .02          HOEHLER   79 IPWA    PI N TO PI N    12/79*

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REFERENCES FOR N*3/2(2300)


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HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                          +KAISER,KOCH,PIETARINEN             /KARLSRUHE IJP
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Δ(2420) 84 N*3/2(2420, JP=11/2+) I=3/2 **H_{311}**

BOTH ROYCHOUDHURY 71 AND BRANSDEN 71 SEE A POSSIBLE RESONANT F35 IN THIS MASS REGION. IN ADDITION BRANSDEN 71 FIND A RESONANT P33 AT 2600 MEV.

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                84  N*3/2(2420) MASS (MEV)

M   6     (2312.0)                   AYED      70 IPWA                     1/71
M   6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M         (2400.)                    BRANSDEN  71 DPWA                     3/72
M         (24C0.)                    ROYCHOUD  71 DPWA                     3/72
M         (2440.)                    OTT       72 MPWA   0 PI-P BKWD ELSTC  2/73
M   1     (2404.)     (63.)          REY       74 MPWA ++ PI+ P 180 DEG CS 10/74
M         (2392.)                    AYED      76 IPWA                    11/77
M          2400.       60.           HENDRY    78 MPWA    PI N TO PI N    12/79*
M          2416.       17.           HOEHLER   79 IPWA    PI N TO PI N    12/79*
M          . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                84  N*3/2(2420) WIDTH (MEV)

W   6      (347.0)                   AYED      70 IPWA                     1/71
W   1      (484.)     (79.)          REY       74 MPWA ++ PI+ P 180 DEG CS 10/74
W          (289.)                    AYED      76 IPWA                    11/77
W           460.      100.           HENDRY    78 MPWA    PI N TO PI N    12/79*
W           340.       28.           HOEHLER   79 IPWA    PI N TO PI N    12/79*
W          . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

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                84  N*3/2(2420) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     N*3/2(2420) INTO PI N                            139+ 938
P2     N*3/2(2420) INTO SIGMA K                        1197+ 493

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                84  N*3/2(2420) BRANCHING RATIOS

R1     N*3/2(2420) INTO (PI N)/TOTAL                    (P1)
R1  6        (0.113)                 AYED      70 IPWA                     1/71
R1  7          (.4)                  OTT       72 MPWA   0 PI-P BKWD ELSTC  2/73
R1  1        (.157)    (.070)    (.035)REY     74 MPWA ++ PI+ P 180 DEG CS 10/74
R1  1    REY 74 DETERMINES (J+1/2)X ONLY, WE HAVE DIVIDED BY 6.           10/74
R1           (.09)                   AYED      76 IPWA                    11/77
R1            .11       .02          HENDRY    78 MPWA    PI N TO PI N    12/79*
R1            .08       .015         HOEHLER   79 IPWA    PI N TO PI N    12/79*
R1         . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

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REFERENCES FOR N*3/2(2420)


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AYED      70 KIEV CONF           R AYED,P BAREYRE, G VILLET           (SACL)IJP

BRANSDEN 71 NP B26 511           ,OGDEN                               (DURH)IJP
    ALSO 70 NP B16 461           ROYCHOUDHURY,PERRIN,BRANSDEN         (DURH)IJP
ROYCHOUD 71 NP B27 125           R K ROYCHOUDHURY,B H BRANSDEN        (DURH)IJP
OTT         72 PL 42B 133        +TRISCHUK,VAVRA,RICHARDS,+ (MCGI,STLO,IOWA)IJP
    ALSO 72 MCGILL THESIS        J. VAVRA                             (MCGI) JP

REY         74 PRL 32 908        REY,LENNOX,POIRIER,PRETZL        (NDAM+MPIM)IP
    ALSO 74 PRL 33 250           REY,LENNOX,POIRIER,PRETZL        (NDAM+MPIM)IP
    ALSO 75 PRD 11 1777          LENNOX,POIRIER,REY,SANDER+  (NDAM+FNAL+ANL)IP

AYED        76 CEA-N-1921        AYED (THESIS)                        (SACL)IJP
HENDRY      78 PRL 41 222        ARCHIBALD W. HENDRY               (IND+LBL)IJP
HOEHLER     79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                 +KAISER,KOCH,PIETARINEN          /KARLSRUHE IJP
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PAPERS NOT REFERRED TO IN DATA CARDS


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BELLAMY  67 PRL 19 476        +BUCKLEY,DOBINSON, +        (WESTFIELD,LOUC) JP
AYED     70 PL 31B 598        +BAREYRE+VILLET                       (SACLAY)
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2420 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

69 N*3/2(2420, JP=) I=3/2 PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW PRECEDING THE N AND DELTA LISTINGS FOR A DISCUSSION OF PRODUCTION EXPERIMENTS.

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                69  N*3/2(2420) MASS (MEV) (PROD. EXP.)

M          (2360.0)                  DIDDENS   63 CNTR    PI+ P TOTAL
M          (2520.0)   (40.0)         ALVAREZ   64 CNTR    PI PHOTOPRCD      7/66
M          (2440.0)                  HOHLER    64 RVUE    DATA + DISP REL
M          (2400.0)        APPROX    WAHLIG    64 OSPK  0 PI-P CH EX
M   B      (2452.0)                  BARGER    66 RVUE    TOTAL + CH EX    11/67
M   B  USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE
M   8  FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
M           2423.0     10.0          CITRON    66 CNTR    PI+ P TOTAL       7/66

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                69  N*3/2(2420) WIDTH (MEV) (PROD. EXP.)

W           (200.0)                  DIDDENS   63 CNTR
W           (245.0)                  HOHLER    64 RVUE                      7/66
W   B       (275.0)                  BARGER    66 RVUE    TOTAL + CH EX    11/67
W            310.0     20.0          CITRON    66 CNTR                      7/66

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                69  N*3/2(2420) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1     N*3/2(2420) INTO PI N                            139+ 938
P2     N*3/2(2420) INTO SIGMA K                        1197+ 493
P3     N*3/2(2420) INTO N*3/2(1232) PI                 1232+ 139
P4     N*3/2(2420) INTO NEUTRON PI+ PI+                 939+ 139+ 139

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                69  N*3/2(2420) BRANCHING RATIOS (PROD. EXP.)

R1     N*3/2(2420) INTO (PI N)/TOTAL                    (P1)
R1         (0.067)       APPROX      DIDDENS   63 CNTR    ASSUMING J=11/2   7/66
R1          0.113     0.0036         CITRON    66 CNTR    ASSUMING J=11/2   7/66
R1  B      (0.12)                    BARGER    67 FIT     ASSUMING J=11/2  11/67
R1  D      (0.163)                   DIKMEN    67 FIT     ASSUMING J=11/2  11/67
R1  D  USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES
R1         (0.06)                    KORMANYOS 67 CNTR    ASSUMING J=11/2  11/67

R2     N*3/2(2420) INTO (PI N)*(NEUTRON PI+ PI+)/(TOTAL**2)
R2                                                      (P1*P4)
R2          0.C195    0.0048         GALLCWAY  68 RVUE                      6/68

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REFERENCES FOR N*3/2(2420) (PROD. EXP.)


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DIDDENS  63 PRL 10 262        +JENKINS, KYCIA, RILEY                   (BNL) I
ALVAREZ  64 PRL 12 710        +BAR-YAM,KERN,LUCKEY,OSBORNE, +    (MIT,CEA)
HOHLER   64 PL 12 149         G HOHLER, J GIESECKE               (KARLSRUHE) I
WAHLIG   64 PRL 13 103        +MANNELLI,SODICKSON,FACKLER,WARD, +    (MIT)
BARGER   66 PR 151 1123       V BARGER, M CLSSON                      (WISC)
CITRON   66 PR 144 1101       +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +   (BNL) I

BARGER   67 PR 155 1792       V BARGER, D CLINE                     (WISC) P
DIKMEN   67 PRL 18 798        F N DIKMEN                              (MICH)
KORMANYO 67 PR 164 1661       KORMANYOS, KRISCH, OFALLON, +     (MICH,ANL) P
GALLOWAY 68 PL 26B 334        K F GALLOWAY                        (INDIANA) I
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PAPERS NOT REFERRED TO IN DATA CARDS


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BAACKE   67 NC 51A 761        J BAACKE, M YVERT           (KARLSRUHE,ORSAY)J-L
DOBROWOL 67 PL 24B 203        DOBROWOLSKI,GUSKOV,LIKHACHEV, +       (DUBNA) P
DOLEN    68 PR 166 1768       R DOLEN, D HORN, C SCHMID                (CIT)
WAHLIG   68 PR 168 1515       M A WAHLIG, I MANNELLI              (MIT,PISA)
    FINAL VERSION OF DATA USED IN WAHLIG 64.  IN CONJUNCTION WITH
    CITRON 66 TOTAL CROSS SECTIONS, THIS CHARGE EXCHANGE DATA GIVES
    CCMPLEX ELASTIC SCATTERING AMPLITUDE AT 0 DEGREES.
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Δ(2500) 124 N*3/2(2500, JP=9/2-) I=3/2 **G_{39}**

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                124  N*3/2(2500) MASS  (MEV)

M         2468.      50.             HOEHLER   79 IPWA    PI N TO PI N    12/79*

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                124  N*3/2(2500) WIDTH  (MEV)

W          480.     100.             HOEHLER   79 IPWA    PI N TO PI N    12/79*

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                124  N*3/2(2500) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     N*3/2(2500) INTO PI N                            139+ 938

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                124  N*3/2(2500) BRANCHING RATIOS

R1     N*3/2(2500) INTO (PI N)/TOTAL                    (P1)              12/79*
R1            .06       .03          HOEHLER   79 IPWA    PI N TO PI N    12/79*

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Data Card Listings

Baryons

For notation, see key at front of Listings. Δ(2500), Δ(>2500), Δ(2750), Δ(2850), Δ(2950)

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                        REFERENCES FOR N*3/2(2500)

HOEHLER   79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                   +KAISER,KOCH,PIETARINEN           /KARLSRUHE IJP

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>2500 MEV REGION – FORMATION EXPERIMENTS

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                  127  N*3/2(>2500) I=3/2

                   WE LIST HERE I=3/2 RESONANCES WITH MASS GREATER THAN
                   ABOUT 2.5 GEV WHICH HAVE BEEN SEEN IN A SINGLE PARTIAL
                   WAVE ANALYSIS ONLY.  ALL RESONANCES WHICH HAVE BEEN
                   OBSERVED IN >1 ANALYSIS AT ABOUT THE SAME MASS ARE
                   GIVEN A SEPARATE LISTING WITH THE APPROPRIATE QUANTUM
                   NUMBERS.

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                  127  N*3/2(>2500) MASS  (MEV)

M          2450.     100.              HENDRY    78 MPWA    PI N  H39        12/79*
M          2850.     150.              HENDRY    78 MPWA    PI N  I311       12/79*
M          3200.     200.              HENDRY    78 MPWA    PI N  K313       12/79*
M          3300.     200.              HENDRY    78 MPWA    PI N  L317       12/79*
M          3700.     200.              HENDRY    78 MPWA    PI N  M319       12/79*
M          4100.     300.              HENDRY    78 MPWA    PI N  N321       12/79*
M          . . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 3.4)

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                  127  N*3/2(>2500) WIDTH  (MEV)

W           500.     200.              HENDRY    78 MPWA    PI N  H39        12/79*
W           700.     200.              HENDRY    78 MPWA    PI N  I311       12/79*
W          1000.     300.              HENDRY    78 MPWA    PI N  K313       12/79*
W          1100.     300.              HENDRY    78 MPWA    PI N  L317       12/79*
W          1300.     400.              HENDRY    78 MPWA    PI N  M319       12/79*
W          1600.     500.              HENDRY    78 MPWA    PI N  N321       12/79*
W          . . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

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                  127  N*3/2(>2500) PARTIAL DECAY MODES

                                                               DECAY MASSES
P1     N*3/2(>2500) INTO PI N                                139+ 938

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                  127  N*3/2(>2500) BRANCHING RATIOS

R1     N*3/2(>2500) INTO (PI N)/TOTAL                      (P1)            12/79*
R1             .08       .02           HENDRY    78 MPWA    PI N  H39      12/79*
R1             .06       .02           HENDRY    78 MPWA    PI N  I311     12/79*
R1             .045      .02           HENDRY    78 MPWA    PI N  K313     12/79*
R1             .03       .01           HENDRY    78 MPWA    PI N  L317     12/79*
R1             .025      .01           HENDRY    78 MPWA    PI N  M319     12/79*
R1             .018      .01           HENDRY    78 MPWA    PI N  N321     12/79*
R1         . . . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

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                        REFERENCES FOR N*3/2(>2500)

HENDRY    78 PRL 41 222         ARCHIBALD W. HENDRY                (IND+LBL)IJP

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Δ(2750) → I₃₁₃

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125  N*3/2(2750, JP=13/2-) I=3/2

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                  125  N*3/2(2750) MASS  (MEV)

M          2650.     100.              HENDRY    78 MPWA    PI N TO PI N    12/79*
M          2794.      80.              HOEHLER   79 IPWA    PI N TO PI N    12/79*
M          . . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

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                  125  N*3/2(2750) WIDTH  (MEV)

W           500.     100.              HENDRY    78 MPWA    PI N TO PI N    12/79*
W           350.     100.              HOEHLER   79 IPWA    PI N TO PI N    12/79*
W          . . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

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                  125  N*3/2(2750) PARTIAL DECAY MODES

                                                               DECAY MASSES
P1     N*3/2(2750) INTO PI N                                 139+ 938

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                  125  N*3/2(2750) BRANCHING RATIOS

R1     N*3/2(2750) INTO (PI N)/TOTAL                       (P1)            12/79*
R1             .05       .01           HENDRY    78 MPWA    PI N TO PI N    12/79*
R1             .04       .015          HOEHLER   79 IPWA    PI N TO PI N    12/79*
R1         . . . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                        REFERENCES FOR N*3/2(2750)

HENDRY    78 PRL 41 222         ARCHIBALD W. HENDRY                (IND+LBL)IJP
HOEHLER   79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN           /KARLSRUHE IJP

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Δ(2850) BUMPS

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85   N*3/2(2850, JP=    +) I=3/2   PRODUCTION EXPERIMENTS

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                  85   N*3/2(2850) MASS (MEV) (PROD. EXP.)

M       (2870.0)                       HOHLER     64 RVUE    DATA + DISP REL
M       (2700.0)         APPROX        WAHLIG     64 OSPK  O PI-P CH EX
M       (2850.0)                       BARDADIN   66 HBC  ++ N* TO P + 3 PIS    7/66
M        2850.0      12.0              CITRON     66 CNTR    PI+ P TOTAL        7/66
M       (2883.)     (26.)     (28.)    REY        74 MPWA ++ PI+ P 180 DEG CS 10/74

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                  85   N*3/2(2850) WIDTH (MEV) (PROD. EXP.)

W        (150.0)                       BARDADIN   66 HBC  ++                    7/66
W         400.0      40.0              CITRON     66 CNTR                       7/66
W        (380.)     (141.)    (201.)   REY        74 MPWA ++ PI+ P 180 DEG CS 10/74

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                  85   N*3/2(2850) PARTIAL DECAY MODES (PROD. EXP.)

                                                              DECAY MASSES
P1     N*3/2(2850) INTO PI N                                139+ 938
P2     N*3/2(2850) INTO P PI PI PI                          938+ 139+ 139+ 139
P3     N*3/2(2850) INTO N PI PI                             938+ 139+ 139

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                  85   N*3/2(2850) BRANCHING RATIOS (PROD. EXP.)

R1     N*3/2(2850) INTO (PI N)/TOTAL                     (P1)
R1    ONLY (J+1/2)*( PI N/TOTAL) MEASURED FOR THIS STATE
R1  B         (0.224)  (0.016)        BARGER     66 RVUE    TOTAL + CH EXC.   11/67
R1             0.261    0.048         CITRON     66 CNTR    TOTAL CROSS.SEC.  11/67
R1  B         (0.40)                  BARGER     67 RVUE    USES KORMANYOS66  11/67
R1  B  USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE
R1  B  FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
R1  C         (0.49)                  DIKMEN     67 RVUE    USES KORMANYOS67  11/67
R1  C  USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES
R1            (0.39)                  DOBROWOLS 67 CNTR    PI+P AT 180 DEG
R1            (0.10)                  KORMANYOS 67 CNTR    PI-P AT 180 DEG.  11/67
R1  D         (0.06) OR LESS  CL=.95  HALDORSE   72 HBC     PP  19  GEV/C     12/72
R1  D   UPPER LIMIT ON ELASTICITY.ALSO FIND J=9/2 OR MORE.
R1            (.28)     (.13)     (.19) REY        74 MPWA ++ PI+ P 180 DEG CS 10/74

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                        REFERENCES FOR N*3/2(2850) (PROD. EXP.)

HOHLER    64 PL 12 149          G HOHLER, J GIESECKE               (KARLSRUHE) I
WAHLIG    64 PRL 13 103         +MANNELLI,SODICKSON,FACKLER,WARD, +     (MIT)
BARDADIN 66 PL 21 357           BARDADIN-OTWINOWSKA,DANYSZ, +        (WARSAW)
BARGER    66 PR 151 1123        V BARGER, M OLSSON                     (WISC)
CITRON    66 PR 144 1101        +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I

BARGER    67 PR 155 1792        V BARGER, D CLINE                    (WISC) P
DIKMEN    67 PRL 18 798         F N DIKMEN                           (MICH)
DOBROWOL 67 PL 24B 203          DOBROWOLSKI,GUSKOV,LIKHACHEV, +     (DUBNA) P
KORMANYO 67 PR 164 1661         KORMANYOS, KRISCH, OFALLON, +    (MICH, ANL) P
HALDORSE 72 NC 10A 468          HALDORSEN,JACOBSEN                   (OSLO) IJ
REY       74 PRL 32 908         REY,LENNOX,POIRIER,PRETZL         (NDAM+MPIM)IP
    ALSO 74 PRL 33 250          REY,LENNOX,POIRIER,PRETZL         (NDAM+MPIM)IP
    ALSO 75 PRD 11 1777         LENNOX,POIRIER,REY,SANDER+  (NDAM+FNAL+ANL)IP

                                PAPERS NOT REFERRED TO IN DATA CARDS

BAACKE    67 NC 51A 761         J BAACKE, M YVERT            (KARLSRUHE,ORSAY)J-L
DOLEN     68 PR 166 1768        R DOLEN, D HORN, C SCHMID                (CIT)
WAHLIG    68 PR 168 1515        M A WAHLIG, I MANNELLI              (MIT,PISA)
    FINAL VERSION OF DATA USED IN WAHLIG 64.  IN CONJUNCTION WITH
    CITRON 66 TOTAL CROSS SECTIONS, THIS CHARGE EXCHANGE DATA GIVES
    COMPLEX ELASTIC SCATTERING AMPLITUDE AT O DEGREES.

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Δ(2950) → K₃₁₅

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126  N*3/2(2950, JP=15/2+) I=3/2

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                  126  N*3/2(2950) MASS  (MEV)

M          2850.     100.              HENDRY    78 MPWA    PI N TO PI N    12/79*
M          2990.     100.              HOEHLER   79 IPWA    PI N TO PI N    12/79*
M          . . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                  126  N*3/2(2950) WIDTH  (MEV)

W           700.     200.              HENDRY    78 MPWA    PI N TO PI N    12/79*
W           330.     100.              HOEHLER   79 IPWA    PI N TO PI N    12/79*
W          . . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.7)

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                  126  N*3/2(2950) PARTIAL DECAY MODES

                                                               DECAY MASSES
P1     N*3/2(2950) INTO PI N                                 139+ 938

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                  126  N*3/2(2950) BRANCHING RATIOS

R1     N*3/2(2950) INTO (PI N)/TOTAL                       (P1)            12/79*
R1             .03       .01           HENDRY    78 MPWA    PI N TO PI N    12/79*
R1             .04       .02           HOEHLER   79 IPWA    PI N TO PI N    12/79*
R1         . . . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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Baryons

Δ(3230), EXOTIC NUCLEONS, Z^*'s, Z_0(1780)

Data Card Listings

For notation, see key at front of Listings.

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                         REFERENCES FOR N*3/2(2950)

HENDRY   78 PRL 41 222          ARCHIBALD W. HENDRY              (IND+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN        /KARLSRUHE IJP

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Δ(3230) BUMPS

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           86  N*3/2(3230, JP=     ) I=3/2  PRODUCTION EXPERIMENTS

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           86  N*3/2(3230) MASS (MEV) (PROD. EXP.)

M        (3230.0)                     CITRON    66 CNTR     PI+ P TOTAL      7/66
M        (3296.)    (79.)     (78.)   REY       74 MPWA ++ PI+ P 180 DEG CS 10/74

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           86  N*3/2(3230) WIDTH (MEV) (PROD. EXP.)

W         (440.0)                     CITRON    66 CNTR                      7/66
W         (687.)  (1043.)   (323.)    REY       74 MPWA ++ PI+ P 180 DEG CS 10/74

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           86  N*3/2(3230) PARTIAL DECAY MODES (PROD. EXP.)

                                                              DECAY MASSES
P1     N*3/2(3230) INTO PI N                                 139+ 938
P2     N*3/2(3230) INTO N PI PI                              938+ 139+ 139

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           86  N*3/2(3230) BRANCHING RATIOS

R1      N*3/2(3230) INTO (PI N)/TOTAL                      (P1)
R1     ONLY (J+1/2)*( PI N/TOTAL) MEASURED FOR THIS STATE
R1  B         (0.03)   (0.01)        BARGER     66 RVUE     TOTAL + CH EXC.  11/67
R1            (0.06)                 CITRON     66 CNTR     TOTAL CROS. SEC. 11/67
R1  B         (0.03)  TO  0.1        BARGER     67 CNTR     USES KORMANYOS66 11/67
R1  B  USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE
R1  B  FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
R1  D         (0.25)                 DIKMEN     67 RVUE     USES KORMANYOS67 11/67
R1  D  USES CNLY RESCNANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES
R1            (.45)     (.09)     (.13) REY     74 MPWA ++ PI+ P 180 DEG CS 10/74

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                      REFERENCES FOR N*3/2(3230) (PROD. EXP.)

BARGER    66 PR 151 1123        V BARGER, M OLSSON                       (WISC)
CITRON    66 PR 144 1101        +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +   (BNL) I
BARGER    67 PR 155 1792        V BARGER, D CLINE                      (WISC) P
DIKMEN    67 PRL 18 798         F N DIKMEN                               (MICH)
REY       74 PRL 32 908         REY,LENNOX,POIRIER,PRETZL          (NDAM+MPIM)IP
     ALSO 74 PRL 33 250         REY,LENNOX,POIRIER,PRETZL          (NDAM+MPIM)IP
     ALSO 75 PRD 11 1777        LENNOX,POIRIER,REY,SANDER+    (NDAM+FNAL+ANL)IP

                      PAPERS NOT REFERRED TO IN DATA CARDS

KORMANYO 67 PR 164 1661         KORMANYOS, KRISCH, OFALLON, +      (MICH,ANL) P
DOLEN     68 PR 166 1768        R DOLEN, D HORN, C SCHMID                (CIT)

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EXOTIC NUCLEONS – 1640 MEV REGION

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                    EXOTIC NUCLEONS

       THIS IS NOT A COMPLETE LIST. WE WILL TABULATE EXOTICS FROM NOW ON

                    EX(1640, JP=     ) I=5/2

                 THIS IS NOT A COMPLETE LIST.  WE TABULATE
                 ONLY FROM 1970 ON.

                 IN A MISSING MASS EXPERIMENT, PI+ P TO PI- X+++,
   BIRULEV 71 FIND NO EVIDENCE FOR EXOTIC (I=5/2) RESONANCES IN THE
   MASS INTERVAL 1.2 TO 2.2 GEV.

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                    EX(1640) MASS (MEV)

M   A   29 1627.       12.             PRICE      70 DBC  -- K-D AT 4.91GEV/C  3/71
M   A  FOUR S. D. EFFECT

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                    EX(1640) WIDTH (MEV)

W   B   29    30.    OR LESS  CL=.90   PRICE      70 DBC  -- PI-PI-N BUMP      3/71
W   B  CROSS SECTION 13.0+-3.9 MICROBARNS

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                    EX(1640) CROSS SECTION LIMITS (MICROBARN)

CS  B        40.    OR LESS           BANNER     70 OSPK +++ PI+P,1.9 GEV/C   7/70
CS  B   I=5/2 LIMIT GIVEN ABOVE IS FOR MASS RANGE 1540-1750 MEV

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                      REFERENCES FOR EX(1640)

BANNER    70 NP B15 205         +CHEZE,HAMEL,TEIGER,ZACCONE +          (SACLAY)
PRICE     70 PL 33B,533         +BERG,SALANT,WATERS,WEBSTER,WEINBERG (VAND)

                      PAPERS NOT REFERRED TO IN DATA CARDS

AMMANN    71 PL    34B 533      +CARMONY,GARFINKEL,GUTAY,MILLER,YEN  (PURD)
BIRULEV   71 SJNP 12  536       +VOVENKO,GUSKOV,DOBROVOLSKII,++      (JINR)
JOHNSON   71 PL    34B 428      D JOHNSON                             (ANL)

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Note on the S = +1 Baryon System

The evidence for S = +1 baryons was thoroughly reviewed in our 1976 edition.[1] More recent measurements, including completed experiments and experiments in progress, have been reviewed by Kelly.[2] Most of the new data which have recently been becoming available have not yet been subjected to partial-wave analysis, and the whole Z* question may be clarified when this is done. In the interim two analyses have been reported by ARNDT 78 and GIACOMELLI1 76. ARNDT 78 is an energy-dependent analysis of K^+p elastic scattering below 2 GeV/c. Although seven resonance poles are found in various waves, only the P_{13} pole at (1796 - 101i)MeV is considered to be a strong Z_1^* candidate, and only this pole is entered in the Data Card Listings below. No information is given on the pole residue and its uncertainty. GIACOMELLI1 76 searched for a Z_1^* decaying into KΔ, but found no evidence for such an effect. The evidence for the existence of Z^*'s thus remains inconclusive.

References

1. Particle Data Group, Rev. Mod. Phys. 48, S188 (1976).
2. R. L. Kelly, in Proceedings of the Meeting on Exotic Resonances (HUPD-7813), eds. I. Endo et al., Hiroshima, 1978.

See the Data Card Listings for other references.

S=1 I=0 EXOTIC STATES (Z_0)

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Z_0(1780) → **P_{01}**

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        95  Z*0(1780, JP=1/2+) I=0
        SEE THE MINI-REVIEW PRECEDING THIS LISTING.

        WILSON 72 AND GIACOMELLI 74 FIND SOME SOLUTIONS
        WITH RESONANT-LIKE BEHAVIOR IN THE P01 PARTIAL WAVE.
        THE EFFECT SEEN IN THE I=0 TOTAL CROSS SECTIONS,
        IF A RESONANCE, MUST HAVE SPIN=1/2, BECAUSE THE
        INELASTIC CROSS SECTION IS VERY SMALL AND THE TOTAL
        CROSS SECTION IS ABOUT 4*PI/K**2.

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        95  Z*0(1780) MASS (MEV)

M           1780.0      10.0          COOL      70 CNTR +  K+P, D TOTAL       1/71
M    D      SEEN                      DOWELL    70 CNTR     K+P,D TOTAL       7/70
M    D      SEE ALSO DISCUSSION OF LYNCH 70                                   7/70
M    W     (1800.)                    WILSON    72 PWA     K+N P01 WAVE       3/72
M    W   ESTIMATE OF PARAMETERS FROM BW + QUADRATIC BACKGROUND FIT TO P01.    3/72
M     1    (1750.)                    CARROLL   73 CNTR    KN I=0 TCS,FIT 1   9/73
M     1    (1825.)                    CARROLL   73 CNTR    KN I=0 TCS,FIT 2   9/73
M     1  FIT 1=FIT OF SINGLE L=1 BW+BACKGROUND TO I=0 TCS FROM .4-1.1 GEV/C   9/73
M     1  FIT 2=FIT OF L=1 AND L=2 BWS TO SAME DATA,SEE Z0(1865) FOR L=2 PART  9/73
M          (1740.)                    GIACOMEL  74  PWA    .38-1.51 GEV/C    10/74

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        95  Z*0(1780) WIDTH (MEV)

W           (565.0)                   COOL      70 CNTR +  K+P, D TOTAL       1/71
W    W      (300.)                    WILSON    72 PWA     K+N P01 WAVE       3/72
W     1     (600.)                    CARROLL   73 CNTR    KN I=0 TCS,FIT 1   9/73
W     1     (845.)                    CARROLL   73 CNTR    KN I=0 TCS,FIT 2   9/73
W           (300.)                    GIACOMEL  74  PWA    .38-1.51 GEV/C    10/74

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Data Card Listings

For notation, see key at front of Listings.

Baryons

$Z_0(1780)$, $Z_0(1865)$, $Z_1(1900)$

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                    95  Z*0(1780) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Z*0(1780) INTO K N                               493+ 939

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                    95  Z*0(1780) BRANCHING RATIOS

R1      Z*0(1780) INTO (K N)/TOTAL                    (P1)
R1             (0.95)             COOL      70 CNTR + K+P, D TOTAL       1/71
R1  W          (0.85)             WILSON    72 PWA    K+N P01 WAVE       3/72
R1   1          (.75)             CARROLL   73 CNTR   IF J=1/2,FIT 1     9/73
R1   1          (.91)             CARROLL   73 CNTR   IF J=1/2,FIT 2     9/73
R1              (.85)             GIACOMEL  74  PWA   .38-1.51 GEV/C    10/74

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                         REFERENCES FOR Z*0(1780)

COOL      70 DUKE CONF 47       R L COOL                               (BNL)
   ALSO 69 PL 30B 564           ABRAMS,COOL,GIACOMELLI,KYCIA,LI +      (BNL)
   ALSO 70 PR D1 1887           COOL,GIACOMELLI,KYCIA,LEONTIC,LI +     (BNL)
DOWELL    70 DUKE 53            J.D. DOWELL                           (BIRM)
WILSON    72 NP B42 445         +GRIFFITHS,HIRATA +    (BGNA+GLAS+ROMA+TRST)
CARRCLL   73 PL 45B 531         +KYCIA,LI,MICHAEL,MOCKETT,RAHM+       (BNL)I
GIACOMEL  74 NP B71 138         GIACOMELLI,+           (BGNA+GLAS+ROMA+TRST)IJP

                         PAPERS NOT REFERRED TO IN DATA CARDS

LYNCH     70 DUKE 9             G LYNCH (REVIEWER OF CR.SEC. DATA)     (LRL)
HIRATA    71 NP B30 157         +GOLDHABER,HALL,SEEGER,THRILLING,WOHL (LBL)IJP
BOWEN     73 PR D7 22           +JENKINS,KALBACH,PETERSEN +      (ARIZ+MICH)
JOHNSON   74 PL 50B 343         JOHNSON,VLASSOPULOS              (CERN,DURH)
CAMERON   75 PALERMO CONF.      +CAPILUPPI+       (BGNA+EDIN+GLAS+PISA+RHEL)IJP
BIGI      76 NP B110 25         +CAMERON+         (BGNA+EDIN+GLAS+PISA+RHEL)IJP

     EXPERIMENTS MAINLY ABOUT ELASTIC CHANNELS --
GOLDHABE 62 PRL 9 135           GOLDHABER,CHINOWSKY,GOLDHABER+   (LRL+UCLA)IJP
RAY       69 PR 183 1183        RAY,BURRIS,FISK,KRAEMER,HILL+     +CARN+BNL
ARMITAGE 72  NAL PAPER 391      +ASTON,DUERDOTH,ELLISON,  +      (MCHS+DARE)
GIACOME1 72 NP B42 437          GIACOMELLI +           (BGNA+GLAS+ROMA+TRST)
GIACOMEL 73 NP B56 346          GIACOMELLI,+           (BGNA+GLAS+ROMA+TRST)
   ALSO 73 BGNA PPT. AE-73/4    GIACOMELLI,GRIFITHS,+  (BGNA+GLAS+ROMA+TRST)
LCNDON    74 PRD 9 1569         LONDON                                 (BNL)IJP
ALEXANDE 75 PL 58B 484          ALEXANDER,BAR-NIR,BENARY+        (TELA+HEID)IJP
DAMERELL 75 NP B94 374          +HOTCHKISS,WICKENS,BENTLEY+      (RHEL,BIRM)

     EXPERIMENTS MAINLY ABOUT INELASTIC CHANNELS --
GIACOMEL 72 NP B37 577          GIACOMELLI +           (BGNA+GLAS+ROMA+TRST)
ARMITAGE 77 NP B123 11          +ASTON,DUERDOTH,ELLISON,FITTON+  (MCHS+DARE)
GLASSER   77 PRD 15 1200        +SNOW,TREVVETT,BURNSTEIN,FU,PETRI+(UMD+IIT)
SAKITT    77 PRD 15 1846        +SKELLY,THOMPSON                       (BNL)

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$Z_0(1865)$ → **D_{03}**

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96   Z*0(1865, JP=3/2-) I=0

     THIS EFFECT IS STRONGLY ASSOCIATED WITH THE K* N
     THRESHOLD.  SEE HIRATA 68 AND 70.  WILSON 72 AND
     GIACOMELLI2 73 REPORT PARTIAL WAVE ANALYSES.
     AARON 73 CLAIMS A RESONANCE IN A MODEL DEPENDENT
     PWA.  SEE ALSO Z*0(1780).
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                    96  Z*0(1865) MASS (MEV)

M          (1860.0)   (15.0)      CARTER    67 THEO   DISPERSION REL.    8/67
M          (1868.0)   (10.0)      COOL      70 CNTR   K+P, D TOTAL       8/67
M          (1830.)                AARON     73 MPWA   I=0 KN .6-1.6G/C   9/73
M    1     (1840.)                CARROLL   73 CNTR   KN I=0 TCS,FIT 2   9/73
M    1  FIT2=FIT OF L=1 AND L=2 BWS TO I=0 TCS FROM .4-1.1 GEV/C.        9/73
M    1  SEE Z0(1780) FOR FIT 1 AND L=1 PART OF FIT 2.                     9/73

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                    96  Z*0(1865) WIDTH (MEV)

W          (200.0)    (50.0)      CARTER    67 THEO                      8/67
W          (160.0)    (30.0)      COOL      70 CNTR                      8/67
W          (100.)                 AARON     73 MPWA   I=0 KN .6-1.6G/C   9/73
W    1      (75.)                 CARROLL   73 CNTR   KN I=0 TCS,FIT 2   9/73

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                    96  Z*0(1865) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Z*0(1865) INTO K N                               493+ 939
P2      Z*0(1865) INTO N K*(892)                         938+ 892

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                    96  Z*0(1865) BRANCHING RATIOS

R1      Z*0(1865) INTO (K N)/TOTAL                    (P1)
R1             (.155)   (.025)    CARTER    67 THEO    IF J=3/2          9/73
R1             (.115)   (.025)    COOL      70 CNTR    IF J=3/2          9/73
R1   1         (.085)             CARROLL   73 CNTR    IF J=3/2,FIT 2    9/73

R2      Z*0(1865) INTO N K*(892)                      (P2)
R2            MAIN INELASTIC DECAY    HIRATA    68 HBC                  11/68

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                         REFERENCES FOR Z*0(1865)

CARTER    67 PRL 18 801         A A CARTER                      (CAVENDISH)
HIRATA    68 PRL 21 1485        HIRATA, WOHL, GOLDHABER, TRILLING     (LRL)
COOL      70 PR D1 1887         COOL,GIACOMELLI,KYCIA,LEONTIC,LI +    (BNL)
   ALSO 66 PRL 17 102           +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
   ALSO 69 PL 30B 564           ABRAMS,COOL,GIACOMELLI,KYCIA,LI +     (BNL)
AARON     73 PRD 7 1401         AARON,RICH,HOGAN,SRIVASTAVA     (LASL+NEAS)IJP
CARROLL   73 PL 45B 531         +KYCIA,LI,MICHAEL,MOCKETT,RAHM+       (BNL)I

                         PAPERS NOT REFERRED TO IN DATA CARDS

HIRATA    70 DUKE   429         +GOLDHABER,SEEGER,TRILLING+WOHL       (LRL)
AARCN     71 PRL 26 407         +AMADO+SILBAR               (NEAS,PENN,LASL)IJP
HIRATA-1 71 NP B33 445          +GOLDHABER,HALL,SEEGER,TRILLING,WOHL  (LBL)
GIACOMEL 72 NP B37 577          GIACOMELLI +           (BGNA+GLAS+ROMA+TRST)
WILSON    72 NP B42 445         +GRIFFITHS,HIRATA +    (BGNA+GLAS+ROMA+TRST)

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S=1 I=1 EXOTIC STATES (Z_1)

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$Z_1(1900)$ → **P_{13}**

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97   Z*1(1900, JP=3/2+) I=1

     THIS EFFECT IS STRONGLY ASSOCIATED WITH THE K-DELTA
     THRESHOLD.  SEE THE MINIREVIEW PRECEDING Z*0(1780)

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                    97  Z*1(1900) MASS (MEV)

M    1     (1932.0)               AYED      70 IPWA    P13,SOL.I         6/70
M    1     (1899.0)               AYED      70 IPWA    P13,SOL.II        6/70
M    1     (2030.0)               AYED      70 IPWA    S11,SOL.III       6/70
M    1      THREE SCLNS IN ORDER OF DECREASING SIGNIFICANCE. THOUGH AYED 70
M    1      GIVE PARAMETERS,THEY CONCLUDE RESONANT INTERPRETATION DOUBTFUL.
M     2    (1830.)                BARNETT   70 IPWA    P13,SOLN III      9/73
M    2      RESONANCE SIGNAL BARELY ABOVE BACKGROUND DUE TO THE LARGE ERRORS
M    2      IN THE AMPLITUDES RESULTING FROM THE ANALYSIS
M           1900.0     10.0       COOL      70 CNTR ++ K+P TOTAL         1/71
M          (1880.)                ALBROW    71 IPWA ++  SOL. GAMMA      10/71
M    K     (1890.)                KATO      71 IPWA    SOL  I(FIT BW)   10/71
M    K     (2040.)                KATO      71 IPWA    SOL II(FIT BW)   10/71
M    K   KATO 71 ESTIMATE RESONANCE PARAMETERS -- UPDATED PHASE SHIFTS   3/72
M    K   PUBLISHED IN MILLER 72.                                          3/72

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                    97  Z*1(1900) WIDTH (MEV)

W    1      (520.0)               AYED      70 IPWA    K+P               6/70
W    1      (357.0)               AYED      70 IPWA    K+P               6/70
W    1      (557.0)               AYED      70 IPWA    K+P               6/70
W     2     (120.)                BARNETT   70 IPWA    P13,SOLN III      9/73
W           (240.0)               COOL      70 CNTR ++ K+- TOTAL         1/71
W           (190.)                ALBROW    71 IPWA ++ SOL. GAMMA       10/71
W    K      (280.)                KATO      71 IPWA    SOL  I(FIT BW)   10/71
W    K      (260.)                KATO      71 IPWA    SOL II(FIT BW)   10/71
         SEE THE NOTES ACCOMPANYING MASSES QUOTED.

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                    97  Z1*(1900) REAL PART OF POLE POSITION             4/75

REE        (1787.)                ARNDT     74 DPWA    K+ P ELASTIC      4/75
REE  3     (1796.)                ARNDT     78 DPWA    K+ P              3/79*
REE  3   SUPERSEDES ARNDT 74.                                            3/79*

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                    97  Z1*(1900) -IMAGINARY PART OF POLE POSITION       4/75

IME         (100.)                ARNDT     74 DPWA    K+ P ELASTIC      4/75
IME  3      (101.)                ARNDT     78 DPWA    K+ P              3/79*

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                    97  Z*1(1900) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Z*1(1900) INTO K N                               493+ 938
P2      Z*1(1900) INTO N*3/2(1232) K                    1232+ 493

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                    97  Z*1(1900) BRANCHING RATIOS

R1      Z*1(1900) INTO (K N)/TOTAL                    (P1)
R1            (0.10) OR LESS      CARTER    67 THEO    DISPERSION REL.   8/67
R1   1        (0.16)              AYED      70 IPWA                      6/70
R1   1        (0.20)              AYED      70 IPWA                      6/70
R1   1        (0.17)              AYED      70 IPWA                      6/70
R1    2        (.12)              BARNETT   70 IPWA    P13,SOLN III      9/73
R1            (0.12) (ASSUMING J=3/2) COOL  70 CNTR ++ K+P TOTAL         1/71
R1            (0.15)              ALBROW    71 IPWA ++ SOL. GAMMA       10/71
R1   K        (0.22)              KATO      71 IPWA    SOL  I(FIT BW)   10/71
R1   K        (0.27)              KATO      71 IPWA    SOL II(FIT BW)   10/71

      SEE NOTES ACCOMPANYING THE MASSES QUOTED.

R2      Z*1(1900) INTO K N*3/2(1232)                  (P2)
R2            MAIN INELASTIC DECAY    BLAND     67 HBC  ++               8/67
R2      NO EVIDENCE, SPEED HAS MINIM. GRIFFITHS 72 HBC     K+P .9-1.5 GEV/C  3/72

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                         REFERENCES FOR Z*1(1900)

BLAND     67 PRL 18 1077        +BOWLER,BROWN,G+S GOLDHABER,SEEGER,+  (LRL)
CARTER    67 PRL 18 801         A A CARTER                      (CAVENDISH)

AYED      70 PL 32B 404         +BAREYRE, FELTESSE, VILLET      (SACLAY)IJP
BARNETT   70 U MD,RPT 70-101    BARNETT,GOLDMAN,LAASANEN,STEINBERG  (UMD)IJP
   ALSO 70 DUKE 443             BARNETT,GOLDMAN,LAASANEN,STEINBERG  (UMD)IJP
COOL      70 PR D1 1887         +GIACOMELLI, KYCIA, LEONTIC, LI, +  (BNL) I
   ALSO 66 PRL 17 102           COOL,GIACOMELLI,KYCIA,LEONTIC,LI +  (BNL)

ALBROW    71 NP  B30 273        +ANDERSON,ALMEHED,...,UDO,WAGNER   (CERN)IJP
   ALSO 70 DUKE  375            ERNE,SENS,WAGNER                   (CERN)IJP
KATO      71 H.E.PHEN.,MORIOND +KOEHLER,...,YOKOSAWA+BURLESON (ANL,NWES)IJP
   ALSO 70 DUKE 367             A. YOKOSAWA                         (ANL)IJP
   ALSO 70 PRL 24 615           KATO,KOEHLER,NOVEY,YOKOSAWA+  (ANL,NWES)IJP

GRIFFITH 72 NP B38 365          +HIRATA,HUGHES +       (BGNA+GLAS+ROMA+TRST)
MILLER    72 NP B37 401         +NOVEY,YOKOSAWA,CUTKOSKY +  (ANL+CARN+NWES)IJP

ARNDT     74 PRL 33 987         ARNDT,HACKMAN,ROPER,STEINBERG    (VPI,UMD)IJP
ARNDT     78 PRD 18 3278        ARNDT,ROPER,STEINBERG            (VPI,UMD)

                         PAPERS NOT REFFERED TO IN Z*1 DATA CARDS

     TOTAL-CROSS-SECTION EXPERIMENTS  ---
BUGG      68 PR 168 1466        +GILMORE,KNIGHT, +          (RHEL,BIRM,CAVE) I
BOWEN     70 PR D2 2599         +CALDWELL, DIKMEN, JENKINS, KALBACH,+(ARIZ) I
BOWEN     73 PR D7 22           +JENKINS,KALBACH,PETERSEN +      (ARIZ+MICH)
CARROLL   73 PL 45B 531         +KYCIA,LI,MICHAEL,MOCKETT,RAHM+        (BNL)
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Baryons

$Z_1(1900)$, $Z_1(2150)$, $Z_1(2500)$, Λ's and Σ's

Data Card Listings

For notation, see key at front of Listings.


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     A K-MATRIX ANALYSIS OF SOME OF THE EARLY K+P DATA ---
HITE      67 THESIS            G E HITE                              (ILLINOIS)

     THEORETICAL AND MODEL DEPENDENT ANALYSES
CARRERAS 70 NP B19 349         B CARRERAS, A DONNACHIE   (DARESBURY, MCHS)
ALCOCK   73 NP B56 301         ALCOCK,COTTINGHAM                       (BRIS)IJP
ALCOCK   76 NP B102 173        ALCOCK,COTTINGHAM,DAVIS                 (BRIS)IJP
ALCOCK   78 J.PHYS. G 4 323    ALCOCK,COTTINGHAM,DAVIS                 (BRIS)IJP

     EXPERIMENTS MAINLY ABOUT INELASTIC CHANNELS ---
BLAND    68 UCRL-18131 THESIS R W BLAND                                (LRL)
BLAND    69 NP B13 595         +BOWLER, BROWN, KADYK, GOLDHABER, +     (LRL)
BLAND    70 NP B18 537         +BOWLER, BROWN, GOLDHABER,              (LRL)
    BLAND 69 AND BLAND 70 REPLACE BLAND 67 AND BLAND 68.
HIRATA-1 71 NP B33 445         +GOLDHABER,HALL,SEEGER,TRILLING,WOHL  (LBL)
BRUNET   72 NP B37 114         BRUNET,NARJOUX,DANYSZ+(CDEF+SACL+LOIC+LOWC)
GRIFFITH 72 NP B38 365         +HIRATA,HUGHES,JACOBS+(BGNA,GLAS,ROMA,TRST)IJP
LOKEN    72 PR D6 2346         +BARISH,GOMEZ,DAVIES,SCHLEIN,+    (CIT,UCLA)
BERTHON  73 NP B63 54          BERTHON,MONTANET,PAUL,SAETRE+   (CERN+SACL)
LEWIS    73 NP B60 283         LEWIS,ALLEN,JACOBS,DANYSZ+ (LOWC+LOIC+CDEF)
LESQUOY  75 NP B99 346         +MULLER,TRIANTIS,BERTHON+       (SACL+CERN)IJP
MUSGRAVE 75 NP B87 365         +PEETERS,SCREINER,WHITMORE,YUTA         (ANL)
GIACOM-2 76 NP B111 365        GIACOMELLI+MANDRIOLI+ (BGNA+GLAS+ROMA+TRST)
ARMITAGE 77 NP B123 11         +ASTON,DUERDOTH,ELLISON,FITTON+ (MCHS+DARE)
GLASSER  77 PRD 15 1200        +SNOW,TREVVETT,BURNSTEIN,FU,PETRI+(UMD+IIT)
SAKITT   77 PRD 15 1846        +SKELLY,THOMPSON                        (BNL)

     THE MAIN ELASTIC SCATTERING AND POLARIZATION EXPERIMENTS --
CARROLL  68 PRL 21 1282        +FISCHER, LUNDBY, PHILLIPS, +    (BNL,RCCH)
ANDERS-1 69 PL 28B 611         ANDERSSON, DAUM, ERNE, LAGNAUX, +    (CERN)
ANDERS-2 69 PL 30B 56          ANDERSSON, DAUM, ERNE, LAGNAUX, +    (CERN)
ASBURY   69 PRL 23 194         +DOWELL, KATO, LUNDQUIST, NOVEY, +(ANL,UMD)
BLAND    69 PL 29B 618         R W BLAND, G GOLDHABER, G H TRILLING  (LRL)
BARBER   70 PL 32B 214         +BROOME, DUFF, HEYMANN, IMRIE,+ (LOUC,RHEL)IJP
GIACOMEL 70 NP B20 301         GIACOMELLI, GRIFFITHS,(BGNA,GLAS,ROMA,TRST)IJP
HALL     70 DUKE    435        +BLAND,GOLDHABER,TRILLING               (LRL)
REBKA    70 PRL 24 160         +ROTHBERG, ETKINS, GLODIS, +           (YALE)IJP
ADAMS    71 PR  D4 2637        +DAVIES,DOWELL,GRAYER,HATTERS+  (BIRM+RHEL)
BARNETT  71 PL 34B 655         +LAASANEN,STEINBERG  +  (UMD+ANL+NWES+FNAL)
EHRLICH  71 PRL 26 925         +ETKIN,GLODIS,HUGHES,KONDO,LU,MORI+  (YALE)
WHITMORE 71 PR D3 1092         +ABRAMS,EISENSTEIN,KIM,OHALLORAN,+    (ILL)
ADAMS    72  NAL PAPER 326     +COX,DAVIES,DOWELL,GRAYER +      (BIRM+RHEL)
CHARLES  72 PL 40B 289         +COWAN,EDWARDS,GIBSON,+     (BRIS,RHEL,SHMP)
   ALSO  72  NAL PAPER 287     CHARLES,COWAN,EDWARDS +     (BRIS+RHEL+SHMP)
DANYSZ   72 NP B42 29          +PENNEY,STEWART,THOMPSON,+ (LOIC,CDEF,LOWC)
ADAMS    73 NP B66 36          ADAMS,COX,DAVIES,DOWELL,+       (BIRM+RHEL)IJP
BARBER   73 NP B61 125         BARBER,BROOME,BUSZA,DAVIES,DUFF+(LOUC+RHEL)
BARNETT  73 PRD 8 2751         BARNETT,LAASANEN+         (UMD+ANL+NWES+FNAL)
CHARLES  73 PURDUE CONF. 179   CHARLES,EDWARDS,+      (SHMP+AARH+RHEL+BRIS)
CAMERON  74 NP B78 93          CAMERON,HIRATA,JENNINGS,+  (GLAS,BGNA,TRST)IJP
YUTA     74 NP B81 189         YUTA,BOCK,MUSGRAVE,PEETERS,SCHREINER,+(ANL)I
ABE      75 PRD 11 1719        +BARNETT,GOLDMAN,LAASANEN+         (UMD,ANL)
ADAMS    75 NP B87 41          +CARTER,COOK,GLASS,GREEN               (WASH)
PATTON   75 PRL 34 975         +BARLETTA,EHRLICH,ETKIN+     (YALE,TOKY,BNL)

     PARTIAL-WAVE ANALYSES (SEE ALSO ADAMS 73 AND CAMERON 74)
CARRERA1 70 NP B23 525         B CARRERAS, A DONNACHIE                (DARE)IJP
   ALSO  70 DUKE 447           +DONNACHIE,KIRSOPP          (DARE+MCHS+EDIN)
ERNE     70 DUKE 375           +SENS,WAGNER                           (CERN)IJP
LEA      71 NP  B26 413        +MARTIN,THOMPSON                  (RHEL,LOUC)IJP
LOVELACE 71 NP  B28 141        +WAGNER                                (CERN)IJP
CUTKOSKY 72  NAL PAPER 210     +HICKS,KELLY,SHIH,JOHNSON    (CARN+ILL+ANL)
EHRLICH  72  NAL PAPER 447     +ETKIN,GLODIS,HUGHES,LU,PATTON +     (YALE)
MARTIN   72  PREPRINT          B.R.MARTIN, C.E.MILLER                 (LOUC)
MARTIN   75 NP B94 413         B R MARTIN                             (LOUC)
CUTKOSKY 76 NP B102 139        CUTKOSKY,HICKS,KELLY,+       (CARN+IIT+ANL)IJP
GIACOM-1 76 NP B110 67         GIACOMELLI+MANDRIOLI               (BGNA+GLAS)IJP

     EARLIER ANALYSES THAT DO NOT INCLUDE RECENT POLARIZATION DATA --
LEA      68 PR 165 1770        LEA, MARTIN, OADES              (RHEL,BNL,CERN)
MARTIN   68 PRL 21 1286        B R MARTIN                              (BNL)
CUTKOSKY 70 PR D1 2547         R E CUTKOSKY, B B DEO     (CARNEGIE-MELLON) I

     LATEST REVIEW TALKS AND PAPERS
LEVISETT 69 LUND CONF 341      R LEVI SETTI  (RAPPORTEUR)        (CHICAGO)
GOLDHABE 70 DUKE    407        G.GOLDHABER (REVIEWER)                 (LRL)
DOWELL   72  NAL REVIEW        REVIEW TALK IN BARYON SESSION         (BIRM)
LOVELACE 72  NAL REVIEW        RAPPORTEUR'S TALK                     (RUTG)
DOWELL   73 PURDUE CONF. 157   DOWELL                                (BIRM)
CUTKOSKY 74 LONDON CONF II-54  CUTKOSKY                              (CARN)
KELLY    75 ANL-HEP-CP-75-58   REVIEW TALK IN BARYON SESSION          (LBL)
URBAN    75 PL 60B 77          URBAN                                  (LBL)
MARTIN   76 OXFORD CONF. 409   RAPPORTEUR'S TALK                     (LOUC)
KELLY    78 HUPD-7813 44       MTG. ON EXOTIC RESONANCES, HIROSHIMA  (LBL)
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$Z_1(2150)$ BUMPS

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93  Z*1(2150, JP=     ) I=1

A SMALL BUMP IN TOTAL CROSS SECTION AT
PK=1.8 GEV/C

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          93  Z*1(2150) MASS (MEV)

M       2150.     20.           ABRAMS    70 CNTR ++ K+P TOTAL       10/71

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          93  Z*1(2150) WIDTH (MEV)

W       (175.)                  ABRAMS    70 CNTR +  K+P TOTAL       10/71

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          93  Z*1(2150) PARTIAL DECAY MODES

                                                     DECAY MASSES
P1    Z*1(2150) INTO K N                             493+ 938

------ --------- --------- --------- --------- --------- --------- --------

          93  Z*1(2150) BRANCHING RATIOS

R1    Z*1(2150) INTO (K N)/TOTAL               (P1)
R1      J IS NOT KNOWN, THE FOLLOWING IS (J+1/2)*P1
R1      (0.04)                  ABRAMS    70 CNTR +  K+P TOTAL       10/71

****** ********* ********* ********* ********* ********* ********* ********
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                        REFERENCES FOR Z*1(2150)
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```
ABRAMS   70 PR  D1 1917        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI +   (BNL)
   ALSO 67 PRL 19 257          ABRAMS,COOL,GIACOMELLI,KYCIA,LEONTIC+ (BNL)
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****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
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$Z_1(2500)$ BUMPS

```
94  Z*1(2500, JP=     ) I=1

A SMALL BUMP IN TOTAL CROSS SECTION AT
PK=2.7 GEV/C

------ --------- --------- --------- --------- --------- --------- --------

          94  Z*1(2500) MASS (MEV)

M       2500.     20.           ABRAMS    70 CNTR ++ K+P TOTAL       10/71

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          94  Z*1(2500) WIDTH (MEV)

W       (160.)                  ABRAMS    70 CNTR ++ K+P TOTAL       10/71

------ --------- --------- --------- --------- --------- --------- --------

          94  Z*1(2500) PARTIAL DECAY MODES

                                                     DECAY MASSES
P1    Z*1(2500) INTO K N                             493+ 938

------ --------- --------- --------- --------- --------- --------- --------

          94  Z*1(2500) BRANCHING RATIOS

R1    Z*1(2500) INTO (K N)/TOTAL               (P1)
R1      J IS NOT KNOWN, THE FOLLOWING IS (J+1/2)*P1
R1      (0.03)                  ABRAMS    70 CNTR ++ K+P TOTAL       10/71

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                        REFERENCES FOR Z*1(2500)
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```
ABRAMS   70 PR  D1 1917        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI +   (BNL)
   ALSO 67 PRL 19 257          ABRAMS,COOL,GIACOMELLI,KYCIA,LEONTIC+ (BNL)
```


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****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
```

Z_1 CROSS SECTION LIMITS

```
     SEE MINIREVIEW PRECEDING Z*0

CS  UNITS MICROBARNS
CS       LESS THAN  50.          BASSOMPIE 68 HBC     K+P TO Z*+ PI+   10/69
CS  A LESS THAN .2    +.3    -.1  ANDERSON  69 ASPK +  PI-P TO K-Z*+   10/69
CS  A      ABOVE LIMIT FOR  M=1.2 TO 1.4 GEV -  CL= 99 P.C.
CS  B LESS THAN 1.4   +1.9   -.5  ANDERSON  69 ASPK +  PI-P TO K-Z*+   10/69
CS  B      ABOVE LIMIT FOR  M=1.5 TO 2.5 GEV

****** ********* ********* ********* ********* ********* ********* ********

                  REFERENCES FOR Z*1 CROSS SECTION LIMITS
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```
BASSOMPI 68 PL 27B 468         BASSOMPIERRE, +              (CERN,BRUXELLES)
ANDERSON 69 PL 29B 136         +BLESER, BLIEDEN, COLLINS, + (BNL,CARNEGIE)
```


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                  PAPERS NOT REFERRED TO IN DATA CARDS
```


```
TYSON    67 PRL 19 255         +GREENBERG,HUGHES,LU,MINEHART,MORI,   (YALE)
MORI     68 PL 28B 152         +GREENBERG,HUGHES,LU,ROTHBERG, +      (YALE)
MORI     69 PR 185 1687        +GREENBERG, HUGHES, LU, MINEHART, +   (YALE)
    MORI 69 REPLACES TYSON 67 AND MORI 68.
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Note on Λ's and Σ's

The number of confirmed resonances is still increasing, but very slowly; in 1978, we added three more states to the Y^* portion of the Baryon Table, and there has been no further increase this year. There remains, however, a large number of proposed, but unconfirmed resonances, and some of the states we enter in the Data Card Listings may really be more than one resonance.

All the Y^*'s proposed in the last few years are only weakly coupled to their two-body decay channels $\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$. For this reason they appear as very small peaks or make no appearance at all in invariant mass distributions. Rather, when the two-body reactions $\bar{K}N \to \bar{K}N$, $\bar{K}N \to \Lambda\pi$, and $\bar{K}N \to \Sigma\pi$ are partial-wave analyzed, some of the amplitudes are found to traverse resonance-like counterclockwise circles. The results of partial-wave analysis give J^P information, whereas a peak seen in an invariant mass distribution or a total cross section often cannot be analyzed for its quantum numbers. We will keep information coming from formation experiments and from production experiments separate whenever necessary.

Formation Experiments

Partial-wave analyses have been performed mainly for the channels $\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$; a few results exist also for ΞK, $\Lambda\omega$, and some quasi-two-body channels. With a few exceptions (e.g., BAILLON 75 and VANHORN 75 for the $\Lambda\pi$ channel), the great majority of the analyses done so far cover rather narrow energy ranges, usually corresponding to a single bubble chamber experiment. A disturbing feature that appears when examining the partial waves obtained in such analyses is that they do not always join smoothly with the partial waves given in analyses done for the same channel over a different energy range.

More ambitious analyses treat all channels simultaneously so that unitarity constraints are automatically obeyed and the resonances appear with the same masses and widths in the different channels. The multi-channel analyses done prior to 1974 (KIM 71, LANGBEIN 72, and LEA 73) included the three two-body channels $\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$, and were carried out in the mass range 1.5 to 1.9 GeV. This is the mass range of a particular bubble chamber experiment (ARMENTEROS 68), the only one which at that time had relatively good statistical accuracy.

In recent years, additional experimental results have been obtained. Bubble chamber experiments now exist with better statistics in the mass range already considered (HEMINGWAY 75, RLIC 77) and with somewhat lower statistical accuracy up to a mass of 2.5 GeV (BELLEFON1 75, 2 75, 77, and 78). However, the most important recent contributions to this field, for the $\bar{K}N$ channel at least, are from electronic counter experiments. These provide results which are difficult if not impossible to get in a conventional bubble chamber experiment. They include high-statistics measurement of the $K^-p \to \bar{K}^0n$ total[1] and differential cross section[2] at low energies, K^-p elastic polarization measurements,[3] and K^-n elastic angular distributions (DECLAIS 77 and Ref. 4).

We may hope that improved partial-wave analyses over a wide energy range will be performed in the near future in order to disentangle the rather unsatisfactory present situation. Even though the unconfirmed resonances (one- and two-star states in Table 1) are often "seen" in several analyses with more or less compatible parameters, the corresponding partial-wave behavior is often very different in each of these analyses. Thus the confidence one has in the existence of these resonances is rather weak.

The three more recent analyses are discussed below. Two of them are multi-channel analyses, fitting data from the three channels, $\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$, and covering a wide mass range.

a) In the analysis of the Rutherford Laboratory-Imperial College collaboration (RLIC 77) the mass range extends from 1480 to 2170 MeV. The data used have been carefully selected in order to eliminate inconsistencies (usually the older and statistically less accurate points have been rejected). Angular distributions were directly used in the fit except when the quality of the data was such that no loss of information occurred by using Legendre coefficients (e.g., $K^-p \to \Sigma^0\pi^0$). In this work, a conventional energy-dependent analysis is performed first for each of the three channels ($\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$). As usual, the presence of a resonance in a partial wave is detected by comparing the goodness of the fit when this wave is parametrized as a smooth background to the alternative fit when a Breit-Wigner is added to the background. The three separate fits are then considered together in order to obtain a real multi-channel analysis. Internal consistency requires that the masses and widths of the resonances be the same in each of the three channels. The final fit has been done with these resonance parameters fixed and equal to a "weighted average" of the three values.

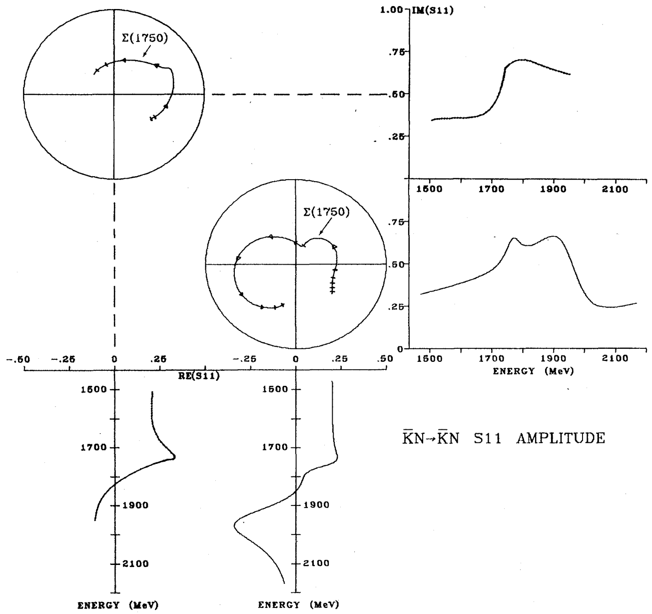
Some suspected resonances are confirmed by this analysis, but many other reported "resonance

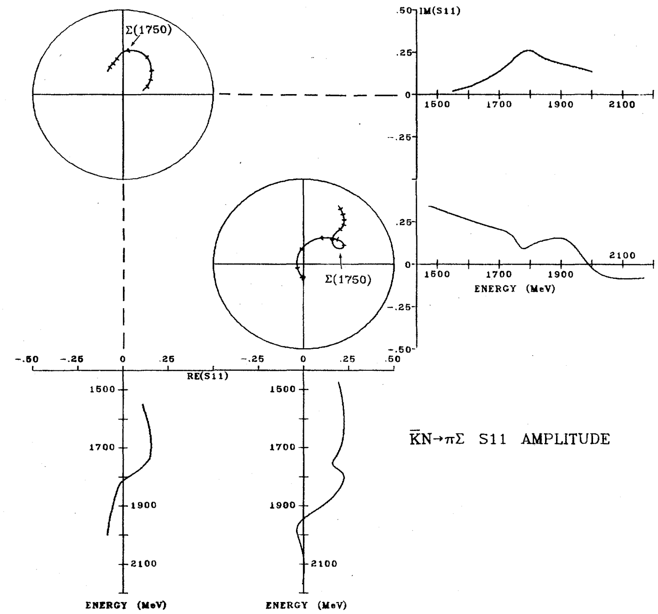
Baryons

Λ's and Σ's

Data Card Listings

For notation, see key at front of Listings.





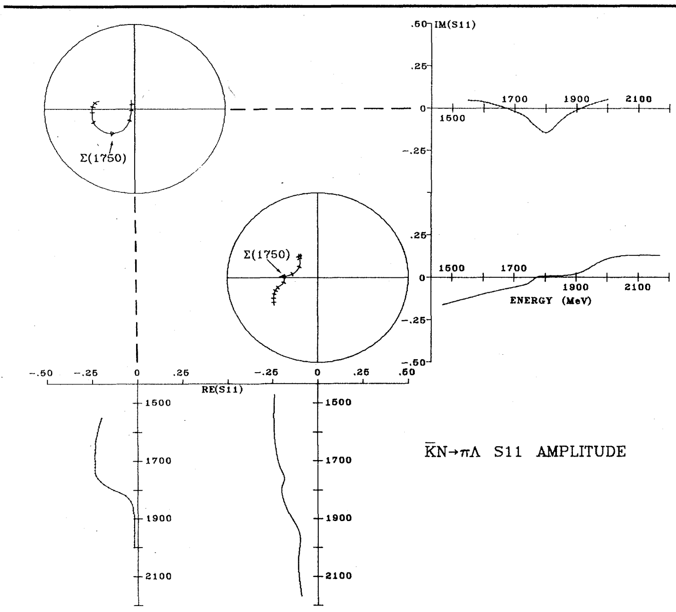


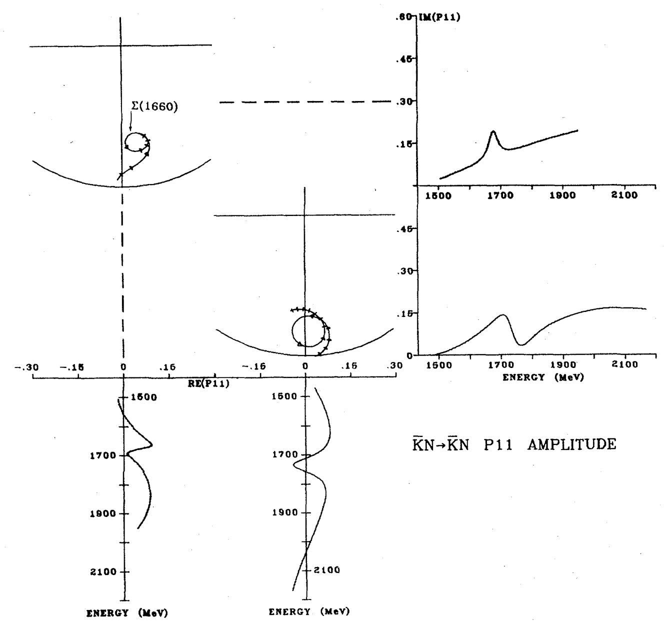
Fig. 1. Amplitudes for $\bar{K}N$ scattering in the S_{11} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the only established resonance in this wave, the Σ(1750), is indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.

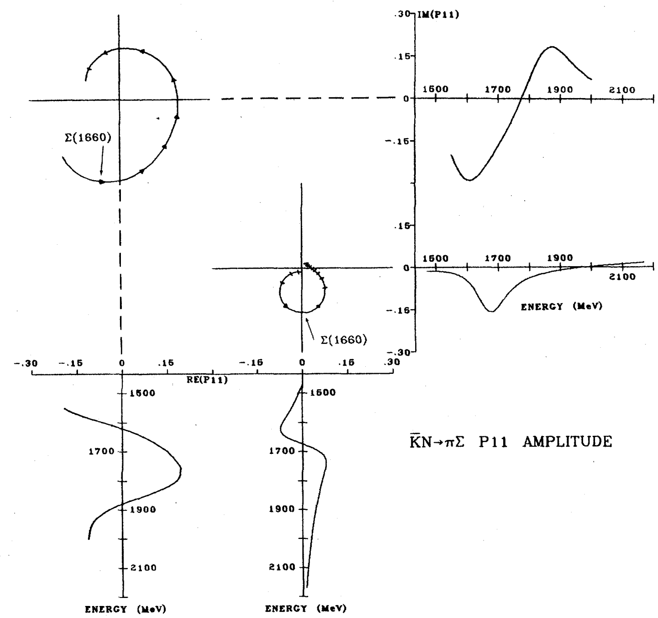
Data Card Listings

For notation, see key at front of Listings.

Baryons

Λ's and Σ's





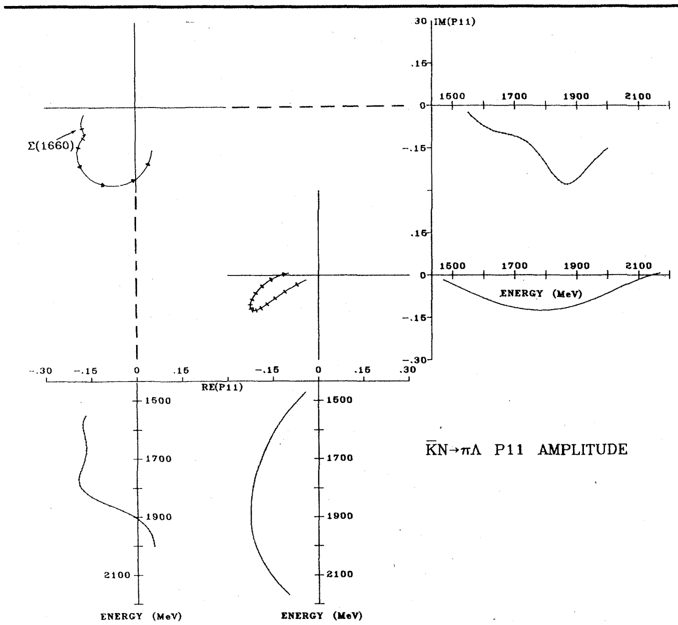
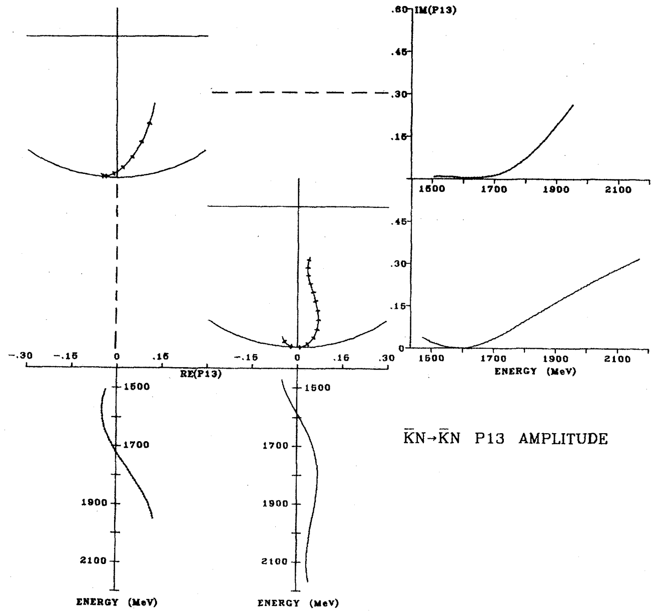
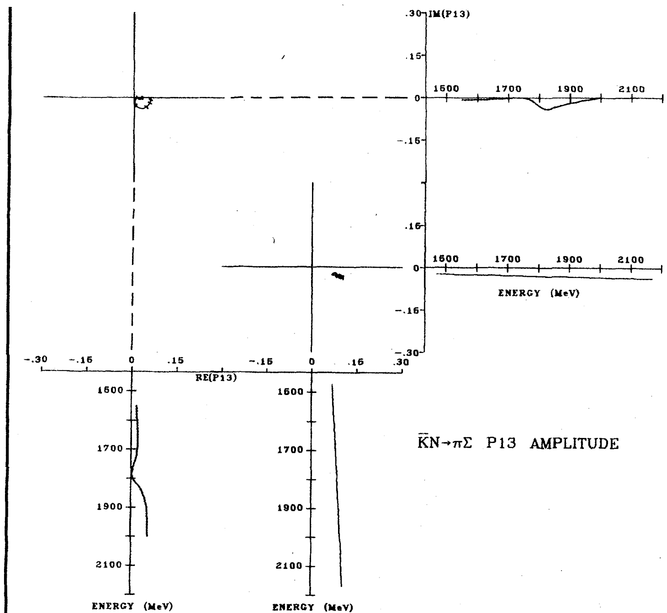


Fig. 2. Amplitudes for K̄N scattering in the P_{11} partial wave. The energy dependence for each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the only established resonance in this wave, the Σ(1660), is indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.

Baryons
Λ's and Σ's

Data Card Listings
For notation, see key at front of Listings.





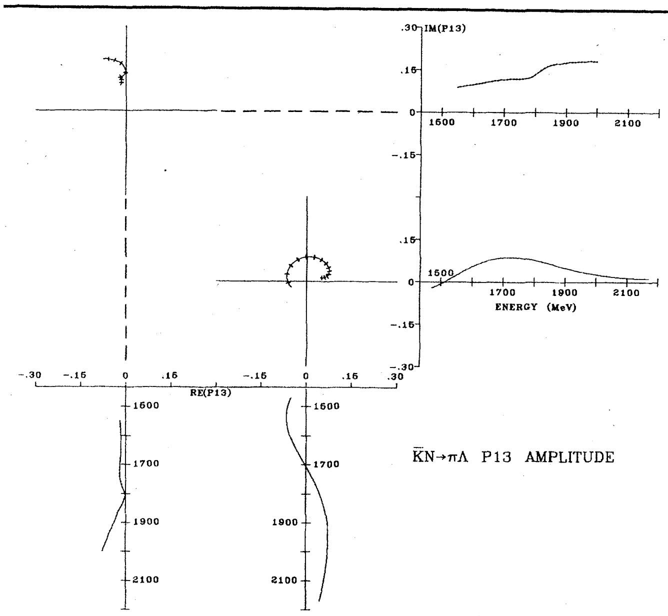


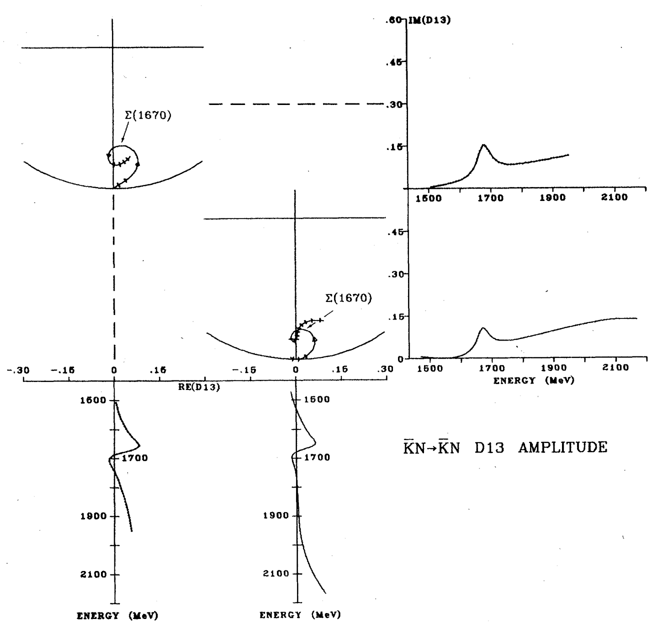
Fig. 3. Amplitudes for $\bar{K}N$ scattering in the P_{13} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots. The only established resonance in this wave, the Σ(1385), lies below elastic threshold and is not shown. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.

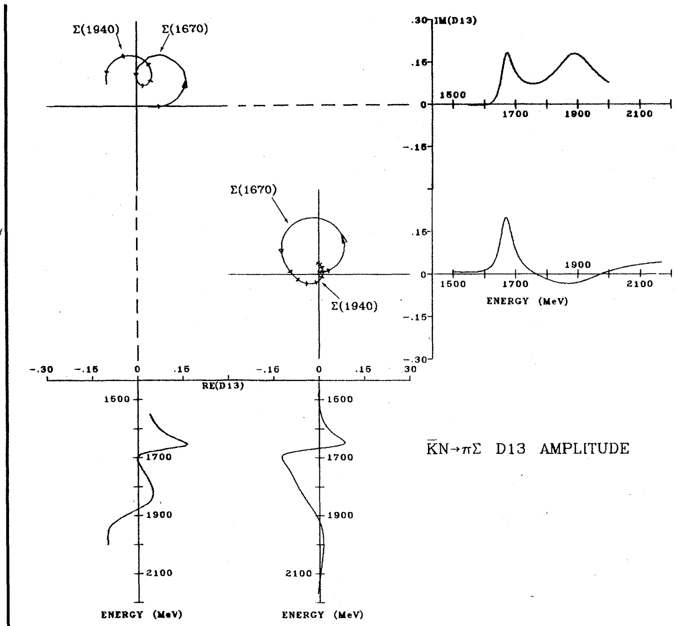
Data Card Listings

For notation, see key at front of Listings.

Baryons

Λ's and Σ's





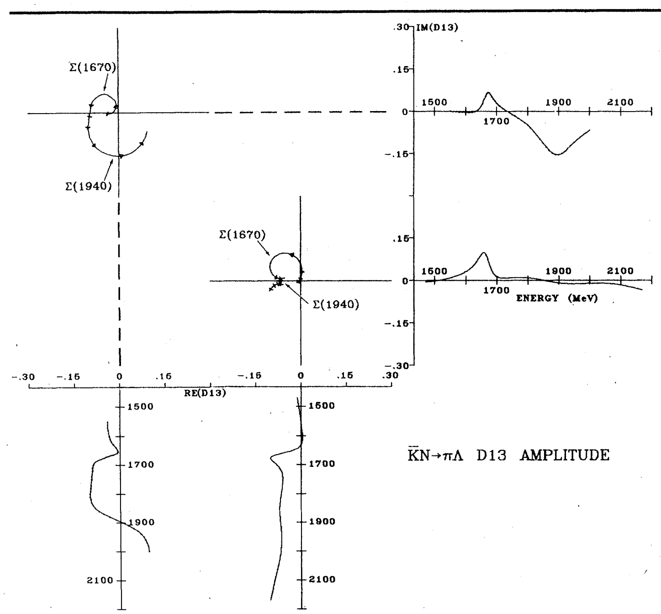


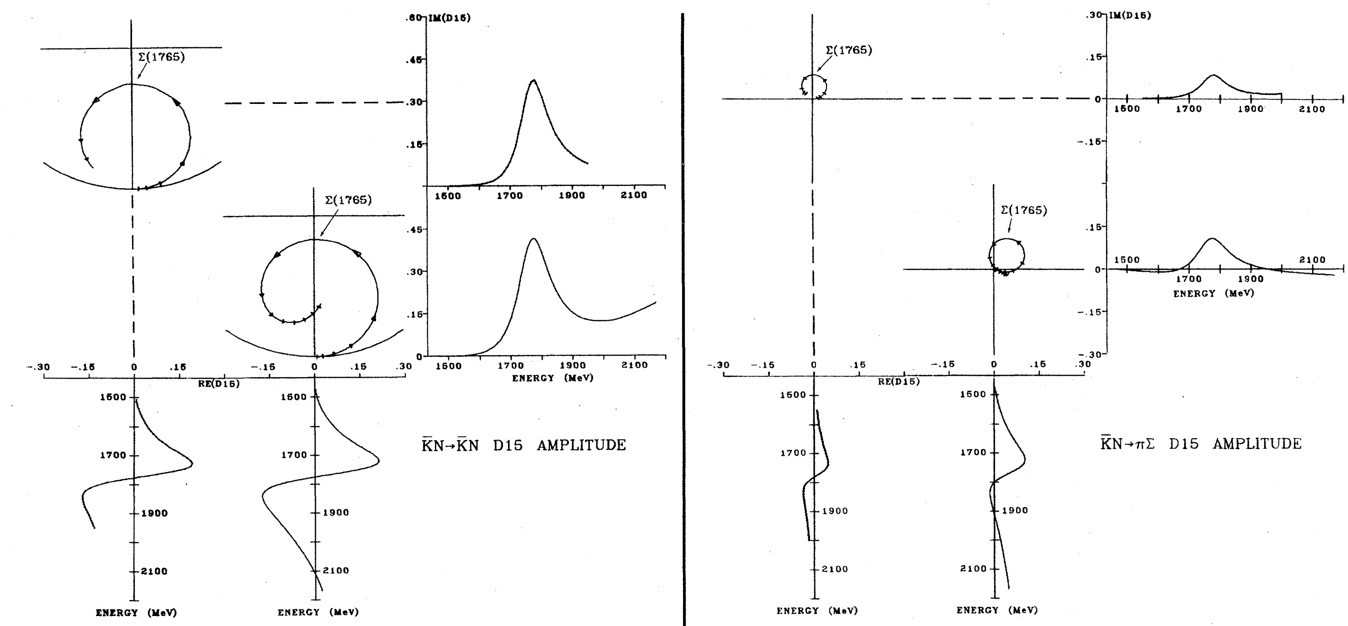
Fig. 4. Amplitudes for $\overline{K}N$ scattering in the D_{13} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the established resonances in this wave, the $\Sigma(1670)$ and the $\Sigma(1940)$, are indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.

Baryons

Λ's and Σ's

Data Card Listings

For notation, see key at front of Listings.



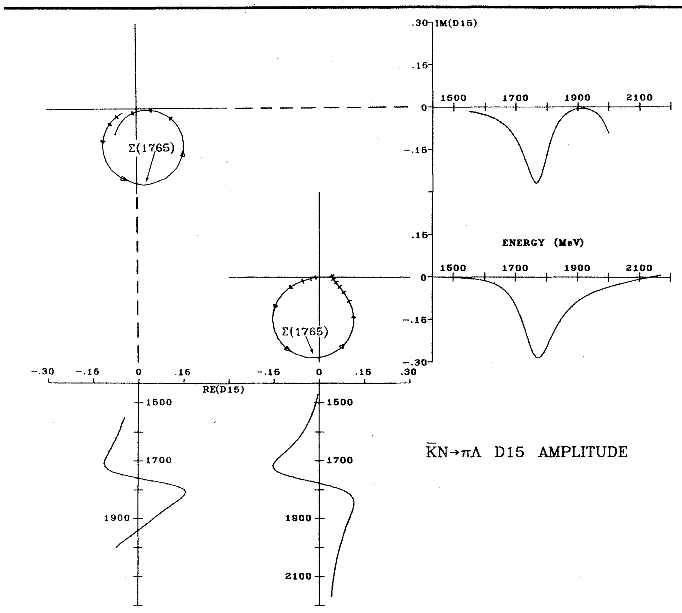


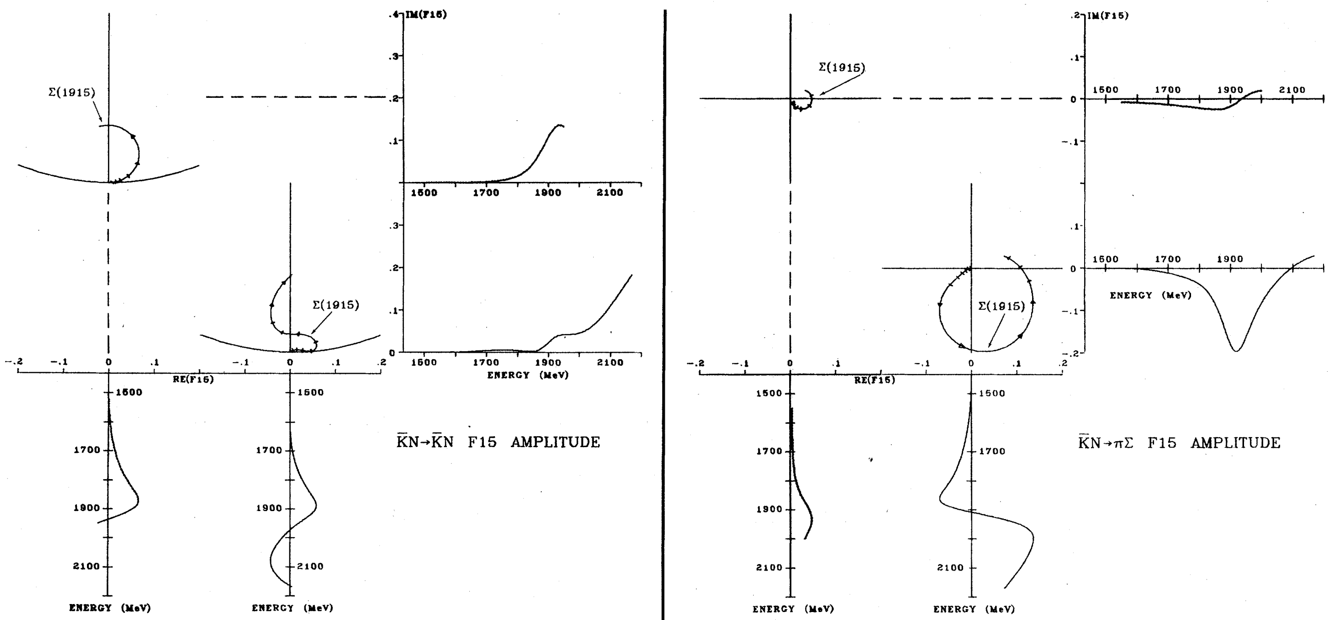
Fig. 5. Amplitudes for $\overline{K}N$ scattering in the D_{15} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the only established resonance in this wave, the Σ(1765), is indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.

Data Card Listings

For notation, see key at front of Listings.

Baryons

Λ's and Σ's



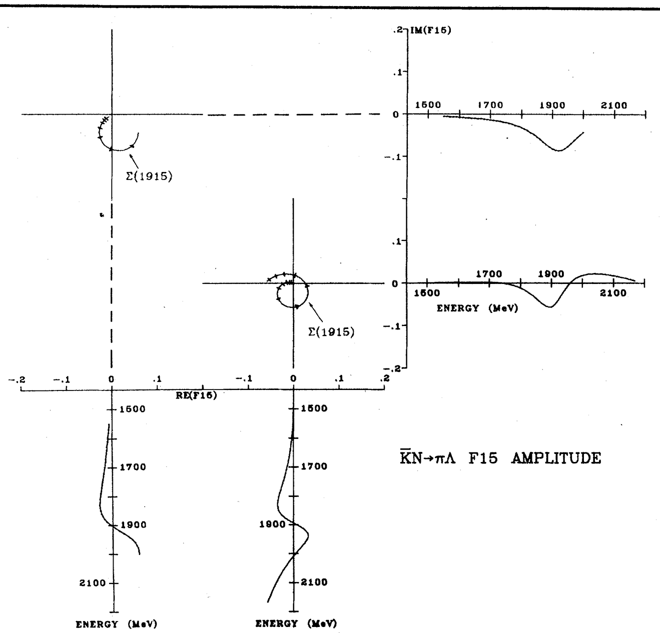
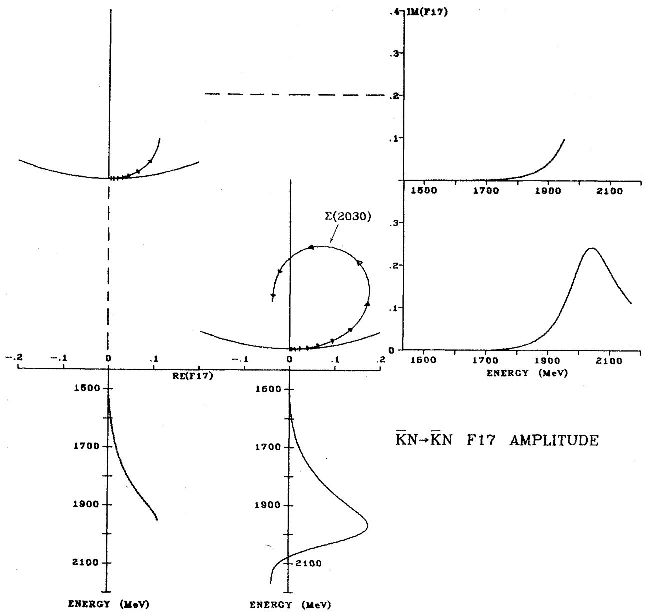
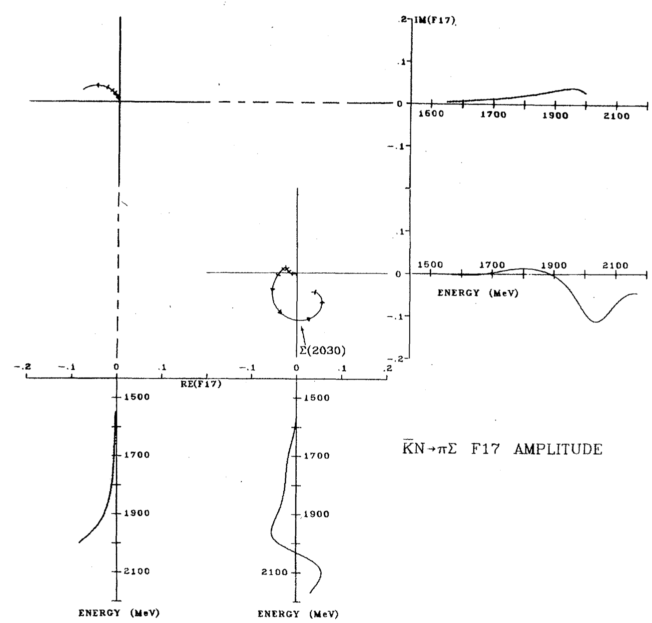


Fig. 6. Amplitudes for $\bar{K}N$ scattering in the F_{15} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the only established resonance in this wave, the Σ(1915), is indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.





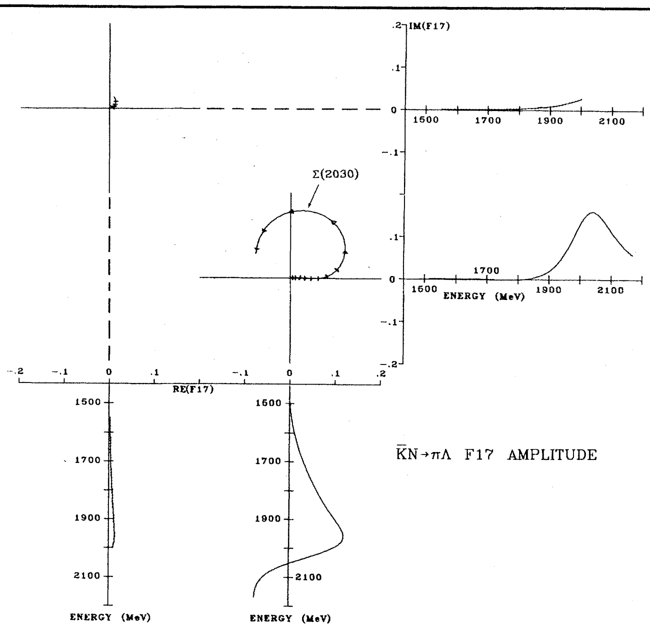


Fig. 7. Amplitudes for $\bar{K}N$ scattering in the F_{17} partial wave. The energy dependence for each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the only established resonance in this wave, the $\Sigma(2030)$, is indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.

Data Card Listings

For notation, see key at front of Listings.

Baryons

Λ's and Σ's

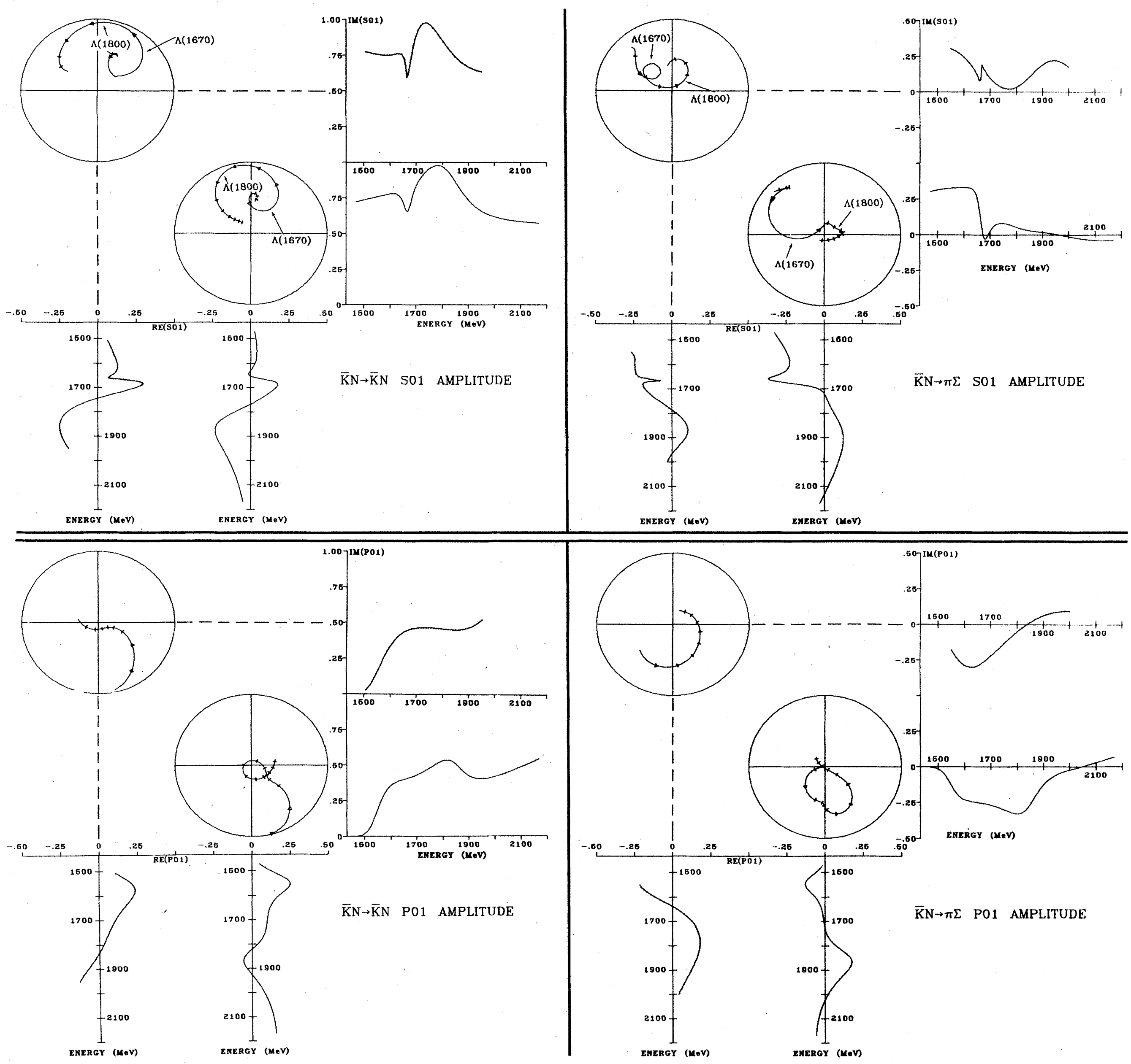


Fig. 8. Amplitudes for $\bar{K}N$ scattering in the S_{01} and P_{01} partial waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the established resonances Λ(1670) and Λ(1800) are indicated. The only other established resonance in these waves is the Λ(1405), which lies below elastic threshold in the S_{01} wave and is not shown. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the πΣ channel.

Baryons

Λ's and Σ's

Data Card Listings

For notation, see key at front of Listings.

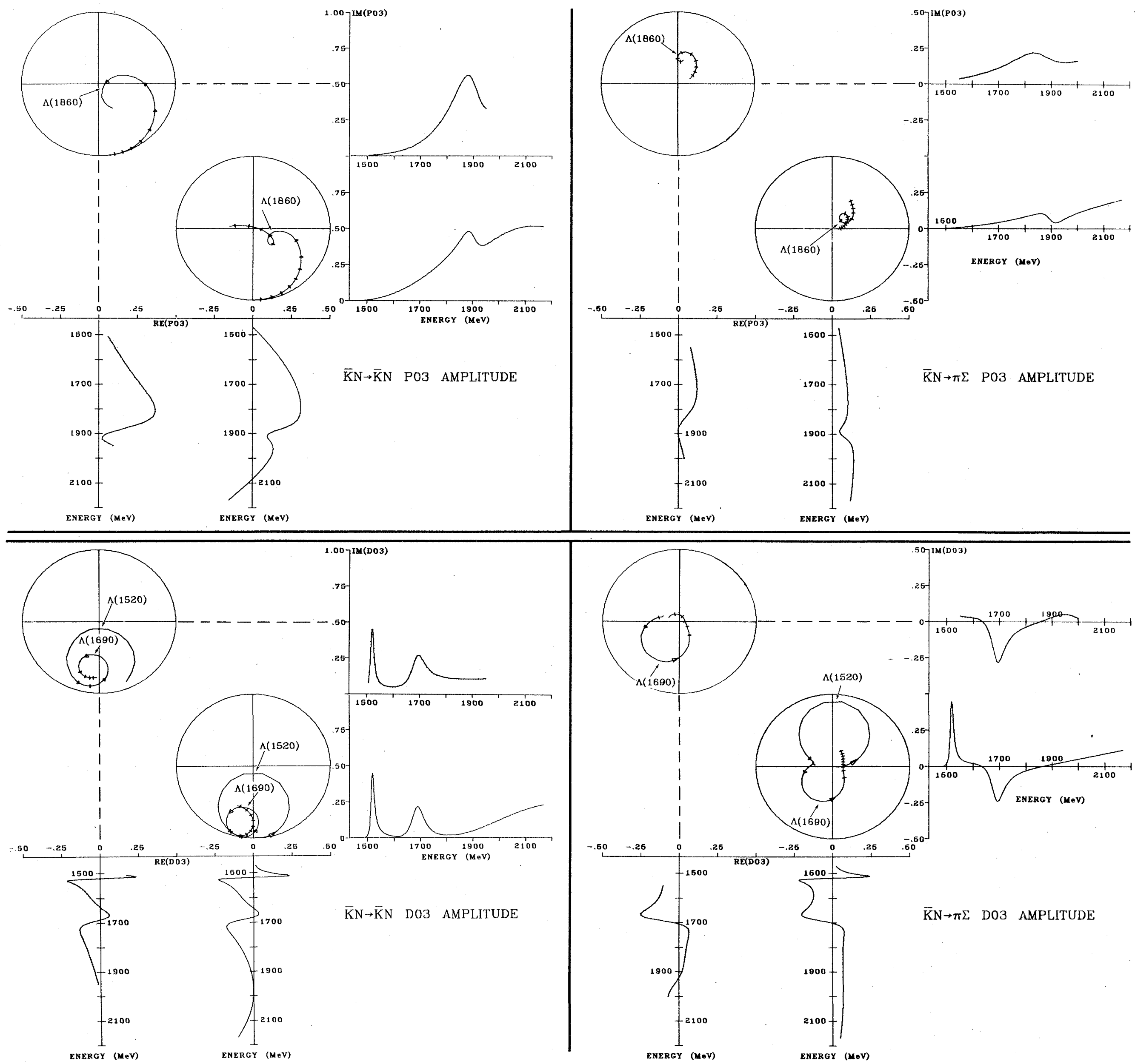


Fig. 9. Amplitudes for $\bar{K}N$ scattering in the P_{03} and D_{03} partial waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the established resonances Λ(1520), Λ(1690), and Λ(1860) are indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the πΣ channel.

Data Card Listings

For notation, see key at front of Listings.

Baryons

Λ's and Σ's

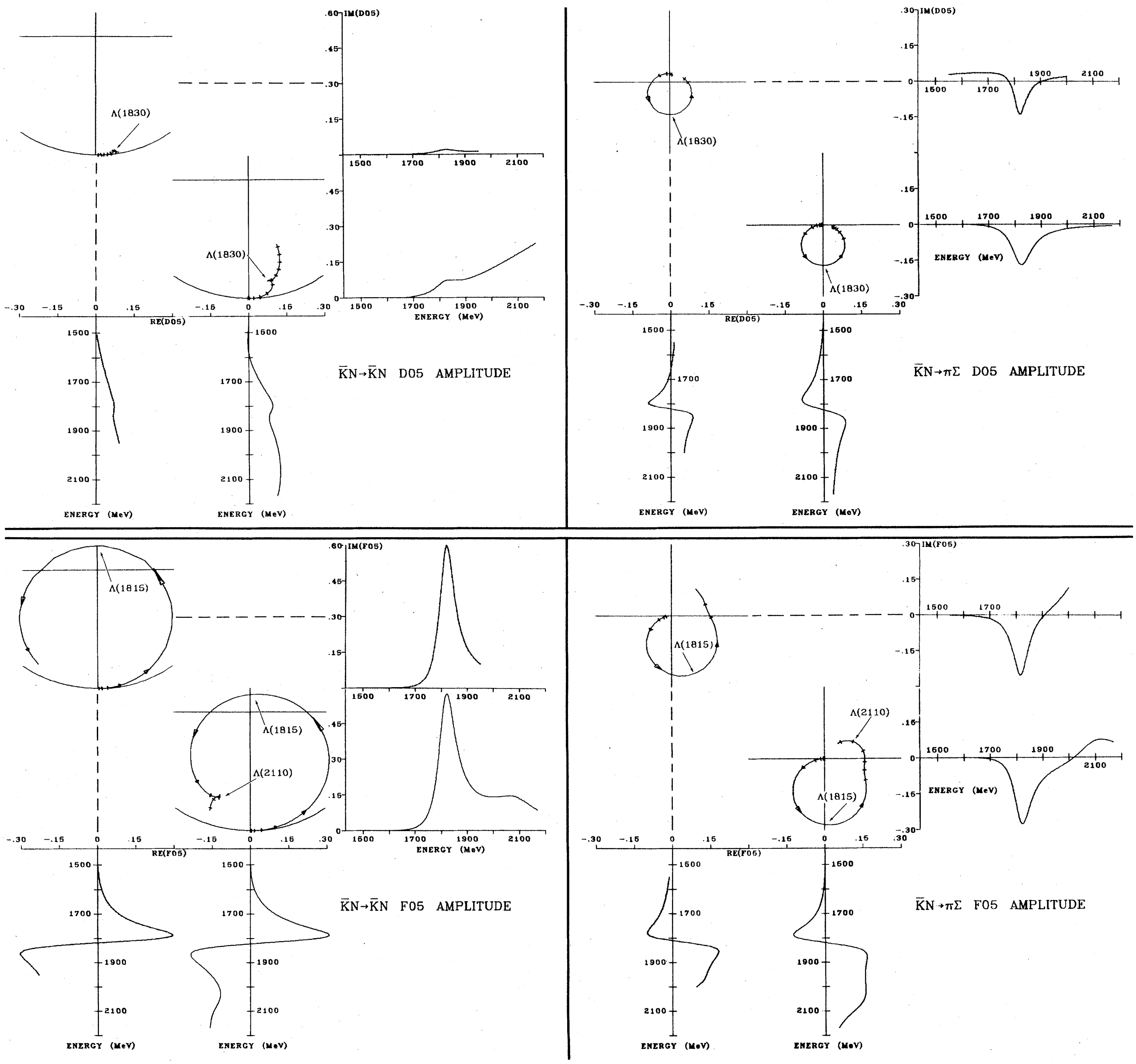


Fig. 10. Amplitudes for $\bar{K}N$ scattering in the D_{05} and F_{05} partial waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the established resonances Λ(1815) Λ(1830), and Λ(2110) are indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the πΣ channel.

Baryons
Λ's and Σ's

Data Card Listings
For notation, see key at front of Listings.

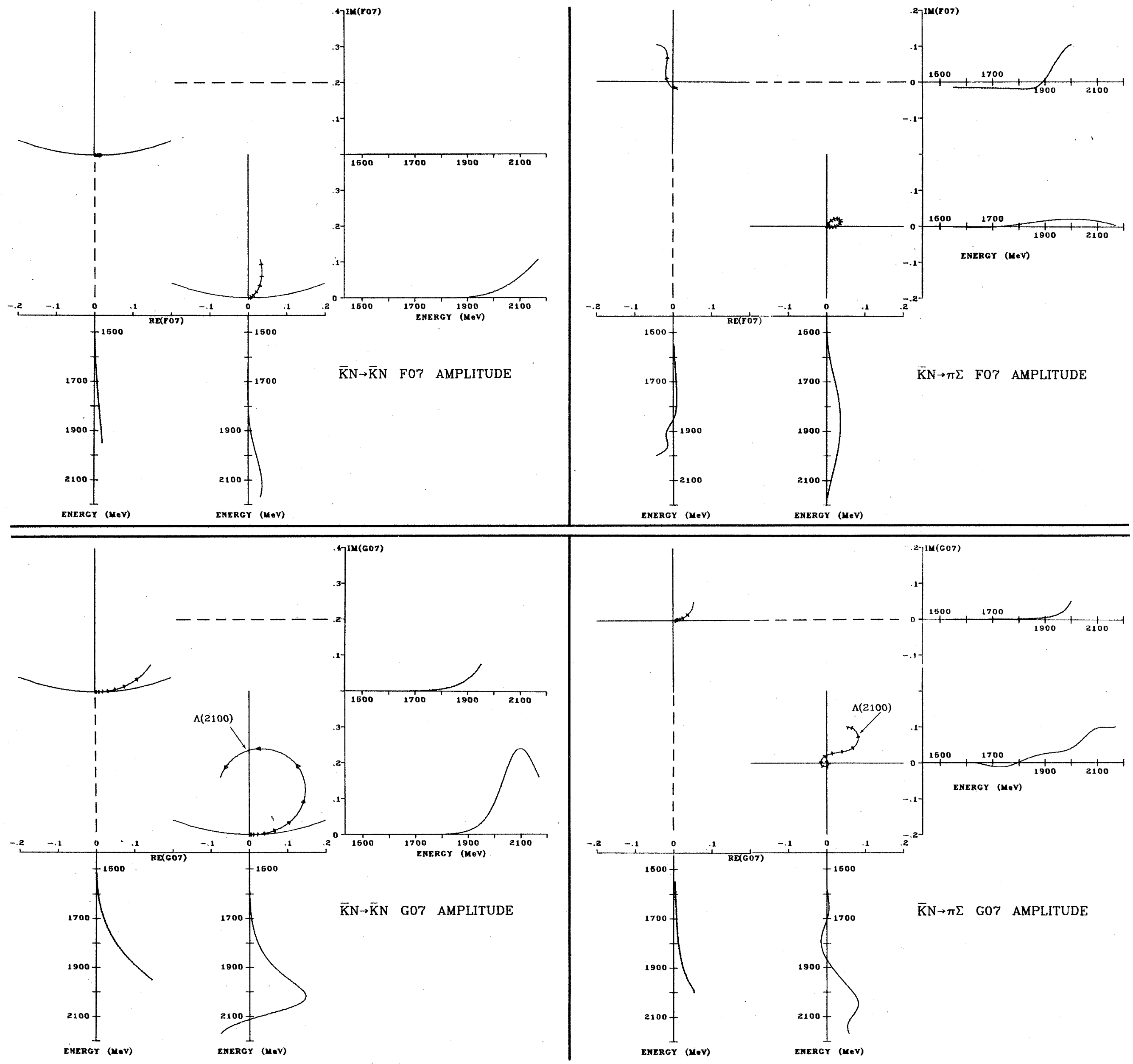


Fig. 11. Amplitudes for $\overline{K}N$ scattering in the F_{07} and G_{07} partial waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the established resonance Λ(2100) is indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the πΣ channel.

effects" are not found and new possible resonances are proposed. The situation in particular for the low partial waves and for low energy is still very confused.

The same group has also published analyses for the main quasi-two-body channels, namely $\Lambda(1520)\pi$, $\Sigma(1385)\pi$, and $N\bar{K}^*(892)$ (CAMERON 77, CAMERON 78, and CAMERON2 78). The statistical accuracy of the data here is lower than for the real two-body channels, and only constrained energy-dependent fits have been made, with most of the well-known resonances being included with fixed parameters. Only one new resonant structure, not observed in real two-body analyses, is suggested, and this is seen in the $N\bar{K}^*$ channel only. Many new couplings of known resonances to quasi-two-body channels were found.

b) The analysis of B. Martin and M. Pidcock (MARTIN 77) is a multi-channel energy-dependent partial-wave analysis with parametrized K-matrix elements. The mass range covered is 1.54 to ~2 GeV. Here the 3 channels $\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$ are always considered simultaneously, a fictitious channel being introduced to account for the global effect of the remaining final states. The $\Lambda\eta$ and $\Sigma\eta$ channels have thresholds within the above mass range and they may induce a "cusp effect". In order not to exclude such a possibility, an additional channel, opening up at the right energy, is also included for the S waves. (It is known that the inelasticities in the S waves are largely due to the production of the η meson, and a similar effect is seen in S-wave πN elastic scattering.) These additional channels, for which no data are fitted, have large cross sections, so it is not clear if such a multi-channel analysis really imposes more stringent unitarity constraints than those already contained in single-channel fits. For this analysis also, a careful selection of the available data has been made. The number of data points which have been fitted amounts to about 12,000. Some of the experimental points have been renormalized in order to suppress unphysical discontinuities in the data. The various channels or types of data may have very different numbers of data points; it would be possible to have a good overall χ^2 with some pieces of data being badly fitted. This was prevented by introducing weights for the various types of data so that each type is reasonably well fitted.

Resonances can appear as poles of the K-matrix, but the K-matrix parameters thus deduced are difficult to compare to those obtained in the more conventional analyses. Two other methods in which the resonance parameters are calculated from the poles of the T-matrix are also given. We list the results of these two methods in the Data Card Listings. It should be noted that no claim for uniqueness of the proposed solution is made; in fact, another solution with almost the same χ^2/N was presented at the Oxford Conference.[5] This latter solution has not been retained as it was not in agreement with present ideas about the low energy behavior of some waves.

c) The single-channel $\bar{K}N$ analysis of ALSTON 78 is worth mentioning because it includes a large amount of new data[1-3] not used by the two analyses mentioned above. It is a conventional energy-dependent analysis, covering the mass range 1.5 to 1.94 GeV, which uses a unitary background parametrization expressed in terms of scattering lengths. The cusp effects observed at the $\Lambda\eta$ and $\Sigma\eta$ thresholds are included by the introduction of a square-root singularity in the energy variation of the S-wave resonance widths. All the confirmed states are observed, but most of the less well established resonances (one and two stars in Table I) are neither observed nor required.

d) Other analyses: Preliminary results of a $\bar{K}N$ single-channel analysis by Hansen *et al.*[6] have been reported. They incorporate more theoretical ingredients than any of the analyses done so far. We have not yet included these results in the Listings. In this energy-independent analysis, invariant amplitudes at fixed t are used as supplementary constraints in the fit. These fixed-t amplitudes themselves are computed using dispersion relations for which not only experimental data but also a first estimate of the partial waves is needed. The method requires that the process of estimating the fixed-t amplitudes and then the partial-wave amplitudes be iterated a few times until full consistency is obtained. This kind of analysis may eventually provide us with more

Baryons
Λ's and Σ's

Data Card Listings
For notation, see key at front of Listings.

reliable partial-wave amplitudes which satisfy fixed-t analyticity and crossing.

In the Listings, the resonance parameters obtained in the latest single-channel analyses are given. These usually cover a limited mass range, but include new data not yet incorporated in the multi-channel analyses described above. In particular, the Saclay-Collège de France collaboration has now published three separate energy-dependent analyses for the channels $\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$ extending up to a mass of 2.5 GeV (BELLEFON 78, 76, and 77, respectively). They indicate that the bumps seen in total cross sections at these higher energies are made up of many resonant states.

For a brief description of the older analyses we refer to the previous editions of this compilation.

Production Experiments

Production experiments are often difficult to analyze for the same reasons as mentioned in the preceding Note on N's and Δ's. I=0 states can only be studied when there is no I=1 state at a similar mass. In the Baryon Table we only use results from production experiments for the lower mass states. Σ(1385) and Λ(1405) lie below the $\bar{K}N$ threshold. Production and formation experiments agree quite well in the case of Λ(1520), and thus they have been combined for this state. There is some disagreement between the two types of experiment in the 1600-to-1700 MeV region. See the Σ(1620) and Σ(1670) mini-reviews for details.

Figures

Argand plots of fifteen S = −1 partial waves are shown in Figs. 1 through 11. The analyses shown were picked largely for illustrative purposes rather than on the basis of our judgment of their quality; for the $\bar{K}N$ channel, we chose to show the amplitudes obtained by RLIC 77 and ALSTON 78, and for the $\Lambda\pi$ and $\Sigma\pi$ channels those from RLIC 77 and MARTIN 77.

Errors on Masses and Widths

Often the quoted errors in partial-wave analyses are only statistical, and the values of masses and widths can change by more than these errors when a new parametrization is used. For this reason we report the values of M, Γ, and x_i obtained by different authors even if they analyze the same data. The spread of these masses and widths is certainly a better estimate of the uncertainties than the statistical errors. Sometimes the errors quoted are obtained by the inspection of various fits done with different hypotheses (see, for example, BERTHON 70, GALTIERI 70, VANHORN 75, RLIC 76). For three states, Λ(1520), Λ(1815), and Σ(1765), there are enough data available to perform an overall fit of the various x_i of the type discussed in the main text (Sec. VII B). In this case we are forced to use the errors, however small they may be, but we warn the reader that the final errors are not to be taken seriously.

In the Baryon Table we choose not to give errors on masses and total widths determined primarily by partial-wave analyses, but, whenever necessary, to show a range of values. As for the branching ratios, we use the errors when needed to perform an overall fit, but we caution the reader.

Conclusions

Table I is an attempt to evaluate the status of the various Y^*'s. The evaluations are of course partly subjective. A blank indicates that there is no corresponding evidence at all. This may mean either that the relevant couplings are small or that the resonance does not really exist. The Baryon Table includes only the well established resonances. It seems clear, however, that whereas any particular one of the questionable resonances may disappear with the next analysis, there are probably many new resonances underlying those already established.

References

1. M. Alston-Garnjost *et al.*, Phys. Rev. D17, 2216 (1978).
2. M. Alston-Garnjost *et al.*, Phys. Rev. D17, 2226 (1978).
3. R. D. Ehrlich *et al.*, Phys. Lett. 71B, 455 (1977).
4. C. Damerell *et al.*, Nucl. Phys. B129, 397 (1977).
5. B. R. Martin, in Proceedings of the Topical Conference on Baryon Resonances (Oxford, 1976), edited by R. T. Ross and D. H. Saxon, pg. 285.
6. P. N. Hansen *et al.*, in Oxford Conference Proceedings (ibid.), pg. 275.

For other references, see the Data Card Listings.

Data Card Listings

For notation, see key at front of Listings.

Baryons

Λ's and Σ's, Λ, Λ(1330), Λ(1405)

TABLE I. STATUS OF Y* RESONANCES

THOSE WITH AN OVERALL STATUS OF *** OR **** ARE INCLUDED IN THE MAIN BARYON TABLE. THE OTHERS AWAIT CONFIRMATION.

			STATUS AS SEEN IN --				
PARTICLE	LIJ	OVERALL STATUS	TOTAL≠ CR. SEC.	KBAR N	LAM PI	SIG PI	OTHER CHANNELS
LAM(1115)	P01	****					WEAK TO N PI
LAM(1330)		DEAD					LAMBDA GAMMA
LAM(1405)	S01	****		****	F	****	
LAM(1520)	D03	****	****	****	O	****	LAM2PI,LAM GAM
LAM(1600)	P01	**		***	R	*	
LAM(1670)	S01	****		****	B	****	LAM ETA
LAM(1690)	D03	****	****	****	I	****	LAM2PI, SIG2PI
LAM(1800)	S01	***		***	D	**	N K*, SIG* PI
LAM(1800)	P01	**		**	D	**	N K*
LAM(1800)	G09	*		*	E	*	
LAM(1800)	PE	*			N		LAM PI PI
LAM(1815)	F05	****	****	****	F	****	SIG(1385) PI
LAM(1830)	D05	****		***	O	****	SIG(1385) PI
LAM(1860)	P03	****	**	****	R	**	N K*, SIG* PI
LAM(2010)		*			B	*	LAM OMG, N K*
LAM(2020)	F07	*		*	I	*	
LAM(2100)	G07	****	****	****	D	***	LAM OMG, N K*
LAM(2110)	F05	***		**	D	*	LAM OMG, N K*
LAM(2325)	D03	*		*	E		LAM OMEGA
LAM(2350)		****	****	****	N		
LAM(2585)		***	***	*			
SIG(1193)	P11	****					WEAK TC N PI
SIG(1385)	P13	****			****	****	
SIG(1480)	PE	*		*	*	*	
SIG(1560)	PE	**			**	**	
SIG(1580)	D13	**	**	*	*		
SIG(1620)	S11	**		**	*	*	
SIG(1660)	P11	***		***	*	**	
SIG(1670)	D13	****	**	****	****	****	SEVERAL OTHERS
SIG(1670)	PE	**		**	**	**	SEVERAL CTHERS
SIG(1690)	PE	**	*	*	**	*	LAM 2-PI
SIG(1750)	S11	***		***	**	*	SIG ETA
SIG(1765)	D15	****	****	****	****	***	SEVERAL OTHERS
SIG(1770)	P11	*		*	*		
SIG(1840)	P13	*		*	**	*	
SIG(1880)	P11	**		**	**		N K*
SIG(1915)	F15	****	***	***	****	***	SIG(1385) PI
SIG(1940)	D13	***		*	***	**	QUASI-2-BODY
SIG(2000)	S11	*			*		N K*, LAM* PI
SIG(2030)	F17	****	****	****	****	**	SEVERAL OTHERS
SIG(2070)	F15	*				*	
SIG(2080)	P13	**			**		
SIG(2100)	G17	*			*	*	
SIG(2250)		****	****	*	*	*	
SIG(2455)		***	***	*			
SIG(2620)		***	***	*			
SIG(3000)		**		*	*		
SIG(3170)	PE	*					MULTI-BODY

**** GOOD, CLEAR, AND UNMISTAKABLE.
*** GOOD, BUT IN NEED OF CLARIFICATION CR NOT ABSOLUTELY CERTAIN.
** NEEDS CONFIRMATION.
* WEAK.

≠ ATTRIBUTED TO THE STATE CLOSEST TO WHERE THE CROSS SECTION PEAKS.

S=−1 I=0 HYPERON STATES (Λ)

Λ

18 LAMBDA(1115, JP=1/2+) I=0

SEE STABLE PARTICLE DATA CARD LISTINGS

Λ(1330) BUMPS

87 Y*0(1330, JP=) I=0 / PRODUCTION EXPERIMENTS

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

→

A PEAK WAS SEEN NEAR 1330 MEV IN THE LAMBDA GAMMA SPECTRUM IN THREE PI-PROPANE EXPERIMENTS (YUNG-CHANG 64, BUBELEV 67, AND BOZOKI 68). ALL MORE RECENT RESULTS INDICATE THAT THERE IS NO RESONANACE NEAR THIS MASS VALUE.

REFERENCES FOR Y*0(1330) (PROD. EXP.)

Y-CHANG 64 DUBNA CONF I 615 YUNG-CHANG, IN, KLADNITSKAYA, + (DUBNA)
BUBELEV 67 PL 24B 246 +CHADRAA, CHUVILO, + (JINR,BUCHAREST,CERN)
DAHL 67 PR 163 1377 DAHL, HARDY, HESS, KIRZ, MILLER (LRL)
BOZOKI 68 PL 28B 360 +FENYVES, GEMESY, + (BUDAPEST,DUBNA)
TAN 69 PRL 23 101 T H TAN (SLAC)
MAYEUR 70 PL 33B 441 +VAN BINST,WILQUET+++ (BRUX,CERN,TUFT)
COLAS 75 NP B91 253 COLAS,FARWELL,FERRER,SIX (ORSA)

Λ(1405) S'01

37 Y*0(1405, JP=1/2-) I=0
PRODUCTION EXPERIMENTS

THIS RESONANCE CAN BE IDENTIFIED WITH THE VIRTUAL BOUND STATE IN THE KBAR-N SYSTEM FOUND IN THE ANALYSIS OF LOW ENERGY K-P INTERACTION. WE LIST SUCH EXPERIMENTS SEPARATELY BELOW. WE USE ONLY PRODUCTION EXPERIMENTS FOR AVERAGING OF MASSES AND WIDTHS.

37 Y*0(1405) MASS (MEV) (PROD. EXP.)

M		(1405.0)		ALSTON	61	HBC	K-P 1.15 BEV/C	
M		(1410.0)		ALEXANDER	62	HBC	PI-P 2.1 BEV/C	
M		(1405.0)		ALSTON	62	HBC	K-P 1.2-.5 BEV/C	
M		(1382.0)	(8.0)	ENGLER	65	HDBC	PI-P, PI+D 1.68	7/66
M		1400.0	24.0	MUSGRAVE	65	HBC	PBAR P 3-4 BEV/C	7/66
M	67	1400.0	5.0	BIRMINGHA	66	HBC	K-P 3.5	9/67
M	120	1405.0	5.0	GALTIERI	68	DBC	K-D 2.1-2.7BEV/C	6/68
M		. . . .						
M	AVG	1402.4	3.5	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
M	STUDENT1	402.4	3.9	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				

37 Y*0(1405) WIDTH (MEV) (PROD. EXP.)

W		(20.0)		ALSTON	61	HBC		7/66
W		35.0	5.0	ALEXANDER	62	HBC		
W		(50.0)		ALSTON	62	HBC		
W		(89.0)	(20.0)	ENGLER	65	HDBC		7/66
W		60.0	20.0	MUSGRAVE	65	HBC		7/66
W	67	50.0	10.0	BIRMINGHA	66	HBC	K-P 3.5	9/67
W	120	35.0	8.0	GALTIERI	68	DBC	K-D 2.1-2.7BEV/C	6/68
W		. . . .						
W	AVG	38.1	3.9	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
W	STUDENT	37.9	4.3	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				

37 Y*0(1405) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	Y*0(1405) INTO SIGMA PI	1197+ 139

REFERENCES FOR Y*0(1405) (PROD. EXP.)

ALSTON 61 PRL 6 698 +ALVAREZ,EBERHARD,GOOD,GRAZIANO, + (LRL) I
ALEXANDE 62 PRL 8 447 ALEXANDER,KALBFLEISCH,MILLER,SMITH (LRL) I
ALSTON 62 CERN CONF 311 +ALVAREZ,FERRO-LUZZI,ROSENFELD, + (LRL) I
ENGLER 65 PRL 15 224 +FISK,KRAEMER,MELTZER,WESTGARD,+ (CARN,BNL) IJ
MUSGRAVE 65 NC 35 735 +PETMEZAS,+ (BIRM,CERN,EPOL,LOIC,SACLAY)

BIRMINGH 66 PR 152 1148 BIRMINGHAM,GLASGOW,LOIC, OXFORD,RUTHERFORD
GALTIERI 68 PRL 21 573 BARBARO-GALTIERI,CHADWICK + (LRL,SLAC)

1405 MEV REGION: EXTRAPOLATIONS BELOW THRESHOLD

24 Y*0(1405, JP=1/2-) I=0 S'01
EXTRAPOLATION BELOW THRESHOLD

SEE NOTE IN Y*0(1405) PRODUCTION EXPERIMENTS. THE DIFFICULTIES IN EXTRAPOLATING FROM THE PHYSICAL REGION TO THE RESONANCE LOCATION ARE DISCUSSED BY DALITZ 67.

THE QUESTION ON WHETHER Y*(1405) IS A KBAR-N BOUND STATE OR A CDD POLE (DALITZ 70, RAJASEKARAN 72 HAS BEEN INVESTIGATED BY CLINE 71, MARTIN 71, GALTIERI 72, AND DOBSON 72. THE LAST TWO PAPERS CONCLUDE THAT THE DATA CANNOT TELL THE DIFFERENCE.

THE (N KBAR)/(PI SIGMA) COUPLING RATIO IS DISCUSSED BY OADES 77.

24 Y*0(1405) MASS (MEV)

M		1410.7	(1.0)	KIM	65	HBC	0-EFF-RANGE FIT	7/66
M		1409.6	(1.7)	SAKITT	65	HBC	0-EFF-RANGE FIT	7/66
M		DATA OF SAKITT ARE USED IN FIT BY KITTEL.						
M		1407.5	(1.2)	KITTEL	66	HBC	0-EFF-RANGE FIT	7/66
M		1403.0	(3.0)	KIM	67	HBC	K MATRIX FIT(KP)	8/67
M		1416.0	(4.0)	MARTIN	69	HBC	CONST. K MATRIX	10/69
M		(1421.0)		MARTIN	70	RVUE	CONST. K MATRIX	6/70
M	1	(1406.)		CHAO	73	DPWA	0-RNG. FIT.SOL B	9/73
M	1	SEE ALSO THE ACCOMPANYING PAPER OF THOMAS73.						9/73

24 Y*0(1405) WIDTH (MEV)

W		37.0	(3.2)	KIM	65	HBC		7/66
W		28.2	(4.1)	SAKITT	65	HBC		7/66
W		34.1	(4.1)	KITTEL	66	HBC		7/66
W		50.0	(5.0)	KIM	67	HBC	K MATRIX FIT(KP)	8/67
W		29.0	(6.0)	MARTIN	69	HBC	CONST. K MATRIX	10/69
W		(20.0)		MARTIN	70	RVUE	CONST. K MATRIX	6/70
W	1	(55.)		CHAO	73	DPWA	0-RNG. FIT.SOL B	9/73
W	1	ASYMMETRIC RESONANCE SHAPE,W/2=41 MEV BELOW RESONANCE,14 MEV ABOVE.						9/73

REFERENCES FOR Y*0(1405) (FROM EXTRAPOLATIONS)

KIM 65 PRL 14 29 J K KIM (COLUMBIA)IJP
SAKITT 65 PR 139 B719 +DAY,GLASSER,SEEMAN,FRIEDMAN, + (UMD,LRL)IJP
KITTEL 66 PL 21 349 W KITTEL, G OTTER, I WACEK (VIENNA)IJP
KIM 67 PRL 19 1074 J KIM (YALE)JP
MARTIN 69 PR 183 1352 B R MARTIN, M SAKITT (LOUC+BNL)
MARTIN 70 NP B16 479 A D MARTIN, G G ROSS (DURHAM)IJP
CHAO 73 NP B56 46 CHAO,KRAEMER,THOMAS,MARTIN (RHEL+CARN+LOUC)IJP
ALSO 73 NP B56 15 THOMAS,ENGLER,FISK,KRAEMER (CARN)IJ

Baryons
Λ(1405), Λ(1520)

Data Card Listings
For notation, see key at front of Listings.

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                         PAPERS NOT REFERRED TO IN DATA CARDS

ABRAMS    65 PR 139 B454        G S ABRAMS, B SECHI-ZORN                 (UMD)IJP
DONALD    66 PL 22 711          + EDWARDS, LYS, NISAR, MOORE    (LIVERPOOL)
KADYK     66 PRL 17 599         +OREN, G+S GOLDHABER, TRILLING           (LRL)IJP
   FIT SOLUTIONS GIVING AN I≠0 S1                          (2 RESONANCE.)
   ABRAMS 65, KADYK 66, AND DONALD 66 SUPPORT THOSE EFFECTIVE-RANGE-
DALITZ    67 PR 153 1617        DALITZ, WONG, RAJASEKARAN   (OXFORD,BOMBAY)
DALITZ    70 DUKE-HR 70 03      R D DALITZ                            (OXF)
CLINE     71 PRL 26 1194        D CLINE,R LAUMANN,J MAPP              (WISC)
MARTIN    71 PL 35B 62          A D MARTIN,B R MARTIN,ROSS (DURH+LOUC+RHEL)
DOBSON    72 PR D6 3256         P N DOBSON,R MCELHANEY                (HAWA)
GALTIERI  72 LBL 555            A.BARBARO-GALTIERI                     (LBL)
RAJASEKA  72 PR D5 610          RAJASEKARAN                           (TATA)
   ALSO EARLIER PAPERS CITED IN RAJASEKARAN72
SHAW      73 PURDUE CONF. 417   SHAW                                  (UCI)IJP
OADES     77 NC 42A 462         G.C.OADES,G.RASCHE              (AARH+ZURI)IJP

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Λ(1520) 38 Y*0(1520, JP=3/2-) I=0 **D'_{03}**

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                 PRODUCTION AND FORMATION EXPERIMENTS AGREE QUITE WELL
                 WITH EACH OTHER, SO THE RESULTS OF THE TWO KINDS OF
                 EXPERIMENTS ARE LISTED TOGETHER HERE.

                  THE DECAY MODE LAMBDA PI PI IS LARGELY DUE TO
    Y*1(1385) PI.  ONLY THE VALUES OF (Y*1(1385) PI)/(LAMBDA PI PI) GIVEN
    BY MAST 72 AND CORDEN 75 ARE BASED ON REAL 3-BODY PARTIAL WAVE ANALYSES
    (THE OLDER RESULTS BEING OBTAINED USING CRUDER METHODS).  THE
    DISCREPANCY BETWEEN THE 2 RESULTS IS ESSENTIALLY DUE TO THE DIFFERENT
    HYPOTHESIS MADE CONCERNING THE SHAPE OF THE EPSILON MESON.

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                 38  Y*0(1520) MASS (MEV)

M       145 1517.2      3.0            GALTIERI  63 DBC     K-D 1.51 BEV/C
M           1519.4      2.0            WATSON    63 HBC     K-P ALL CHANNELS
M        29 1520.0      4.0            ALMEIDA   64 HBC     K-P 1.45 BEV/C
M          (1511.0)   (15.0)           MUSGRAVE  65 HBC     PBAR P 3-4 BEV/C  7/66
M        30(1510.0)    (2.0)           BIRMINGHA 66 HBC     K-P 3.5           9/67
M   B       1517.2      1.2            BURKHARDT 69 HBC     K-P .8-1.2 GEV/C 10/69
M   B             QUOTED ERROR INCREASED TO ACCOUNT FOR DISAGREEMENT BETWEEN
M   B             TWO MEASUREMENTS DONE BY SAME AUTHORS (K-P AND SIGMA PI)
M          (1519.)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
M      1669 1517.+/-1. TO 1521.+/-1.   BERTHON   74 HBC   0 QUASI 2 BODY CS  10/74
M      2000 1519.4       .3            CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75
M        4K 1519.7      0.3            CAMERON   77 HBC     K-P 0.96-1.36GEV  1/78
M           1519.       1.             RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M           1520.        .5            ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M        5K 1517.8      1.2            BARLAG    79 HBC     K-P AT 4.2 GEV/C 12/79*
M           . . . . . . . . . .
M   AVG     1519.49     0.23    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
M   STUDENT1519.50      0.21    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                 38  Y*0(1520) WIDTH (MEV)

W            16.4       2.0            WATSON    63 HBC
W           (19.0)    (19.0)           MUSGRAVE  65 HBC                       7/66
W       30  (50.0)    (10.0)           BIRMINGHA 66 HBC     K-P 3.5           9/67
W           (18.0)    OR LESS          DAHL      67 HBC                       9/66
W            14.7       1.8            BURKHARDT 69 HBC     K-P .8-1.2 GEV/C 10/69
W           (16.)                      KIM       71 DPWA    K-MATRIX ANAL.    3/71
W     2000   15.5       1.6            CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75
W       4K   16.3       0.5            CAMERON   77 HBC     K-P 0.96-1.36GEV  1/78
W            15.         .5            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W            15.4        .5            ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W  R   677   14.        3.             BARLAG    79 HBC     K-P AT 4.2 GEV/C 12/79*
W  R     FROM BEST RESOLUTION SAMPLE OF LAMBDA PI PI EVENTS ONLY.            12/79*
W           . . . . . . . . . .
W   AVG      15.55      0.28    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W   STUDENT  15.52      0.33    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                 38  Y*0(1520) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     Y*0(1520) INTO KBAR N                               497+ 939
P2     Y*0(1520) INTO SIGMA PI                            1197+ 139
P3     Y*0(1520) INTO LAMBDA PI PI                        1115+ 139+ 139
P4     Y*0(1520) INTO LAMBDA GAMMA                        1115+   0
P5     Y*0(1520) INTO SIGMAO GAMMA                        1192+   0
P6     Y*0(1520) INTO SIGMA PI PI                         1197+ 139+ 139
P7     Y*0(1520) INTO (Y*1(1385)+PI)                      1384+ 139
P8     Y*0(1520) INTO Y*1(1385) PI INTO LAMBDA PI PI      1115+ 139+ 139
         NOTE THAT P8/P7 IS THE BRANCHING FRACTION FOR Y*1(1385) INTO LM PI   9/73
P9     Y*0(1520) INTO LAMBDA EPSILON                      1518+1300

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.4503+-.0056					
P 2	-.6215	.4199+-.0064				
P 3	-.2288	-.3931	.0945+-.0043			
P 4	-.0653	-.1167	-.0468	.0078+-.0014		
P 5	-.1675	-.2995	-.1202	-.0248	.0190+-.0034	
P 6	-.0249	-.0446	-.0179	-.0037	-.0095	.0086+-.0005

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                 38  Y*0(1520) BRANCHING RATIOS

R1      Y*0(1520) INTO (SIGMA PI)/(KBAR N)                   (P2)/(P1)
R1           1.72       .78            MUSGRAVE  65 HBC                       8/67
R1           0.96      0.20            DAHL      67 HBC      PI-P 1.6-4 GEV/C  9/66
R1           0.73      0.11            DAUBER    67 HBC      K-P AT 2.GEV/C    8/67
R1           1.06       .14            SCHEUER   68 DBC    0 K-N 3 GEV/C      10/69
R1           0.82      0.08            BURKHARDT 69 HBC      K-P .8-1.2 GEV/C 10/69
R1          (1.06)     (.12)           BERTHON   74 HBC    0 QUASI 2 BODY CS  10/74
R1   4        .98       .03            RLIC      77 DPWA     KBAR N MULTICHNL  1/76
R1   4  KBAR N TO SIGMA PI AMPLITUDE AT RESONANCE IS +.46 +/- .01             1/76
R1           . . . . . . . . . .
R1  AVG      0.951     0.044    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R1  STUDENT  0.957     0.032    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT      0.933     0.023  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2      Y*0(1520) INTO (LAMBDA PI PI)/(KBAR N)               (P3)/(P1)
R2           0.17      0.05            DAHL      67 HBC      PI-P 1.6-4 GEV/C  9/66
R2           0.21      0.18            DAUBER    67 HBC      K-P AT 2.GEV/C    8/67
R2            .19       .04            SCHEUER   68 DBC    0 K-N 3 GEV/C      10/69
R2           0.22      0.03            BURKHARDT 69 HBC      K-P .8-1.2 GEV/C 10/69
R2          (0.2)                      KIM       71 DPWA     K-MATRIX ANAL.    3/71
R2          (.27)      (.13)           BERTHON   74 HBC    0 QUASI 2 BODY CS  10/74
R2           . . . . . . . . . .
R2  AVG      0.202     0.021    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  STUDENT  0.202     0.024    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2  FIT      0.210     0.010  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R3      Y*0(1520) INTO (SIGMA PI)/(LAMBDA PI PI)             (P2)/(P3)
R3           4.5       1.0             ARMENTERO 65 HBC                       7/66
R3           3.3       1.1             BIRMINGHA 66 HBC      K-P 3.5           9/67
R3           3.9       1.0             UHLIG     67 HBC      K-P .9-1.0 BEV/C  9/66
R3           . . . . . . . . . .
R3  AVG      3.94      0.59     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  STUDENT  3.94      0.65     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3  FIT      4.44      0.24   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R4      Y*0(1520) INTO (LAMBDA GAMMA)/TOTAL (PERCENT)       (P4)
R4      238  0.80      0.14            MAST      68 HBC    0 USING ELAST=.45  11/68
R4           . . . . . . . . . .
R4  FIT      0.78      0.14     FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5      Y*0(1520) INTO (SIGMAO GAMMA)/TOTAL (PERCENT)       (P5)
R5   S       2.0        .35            MAST      68 HBC      SEE NOTE S       10/69
R5   S      RATIOS CALCULATED FROM R4,ASSUMING SU(3). NEEDED TO CONSTRAIN
R5   S      ALL THE Y*0(1520) BRANCHING RATIOS TO BE UNITY.
R5           . . . . . . . . . .
R5  FIT      1.90      0.34     FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6      Y*0(1520) INTO (KBAR N)/TOTAL                        (P1)
R6           0.29      0.05            WATSON    63 HBC      K-P ALL CHANNELS 10/71
R6            .447      .018           GALTIERI  69 HBC      K- P .28-.45 G/C 10/69
R6           0.47      0.03            COLLEY    71 DBC      K-N 1.5 GEV PROD 10/71
R6          (0.45)                     KIM       71 DPWA     K-MATRIX ANAL.    3/71
R6            .448      .014           CORDEN    75 DBC      K- D 1.4-1.8GV/C  4/75
R6           (.42)                     MAST      76 HBC    0 K- P CEX          1/76
R6            .47       .01            RLIC      77 DPWA     KBAR N MULTICHNL  1/76
R6            .45       .03            ALSTON    78 DPWA     KBAR N ELASTIC    1/78
R6           . . . . . . . . . .
R6  AVG      0.457     0.012    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R6  STUDENT  0.4577    0.0083   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R6  FIT      0.4503    0.0056 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R7      Y*0(1520) INTO (SIGMA PI)/TOTAL                      (P2)
R7           0.55      0.09            WATSON    63 HBC      K-P ALL CHANNELS 10/71
R7           0.418      .017           GALTIERI  69 HBC    0 K-P .28-.45GEV/C  6/69
R7           0.43     (0.03)           COLLEY    71 DBC      K-N 1.5 GEV PROD 10/71
R7          (0.46)                     KIM       71 DPWA     K-MATRIX ANAL.    3/71
R7   3        .426      .014           CORDEN    75 DBC      K- D 1.4-1.8GV/C  4/75
R7   3  SUPERSEDES COLLEY 71                                                  1/76
R7           . . . . . . . . . .
R7  AVG      0.425     0.011    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R7  STUDENT  0.424     0.012    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R7  FIT      0.4199    0.0064 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R8      Y*0(1520) INTO (SIGMA PI PI)/TOTAL                   (P6)
R8            .010      .0015          GALTIERI  69 HBC    0 K-P .28-.45GEV/C 10/69
R8   2        .0085     .0006          MAST2     73 MPWA     K-P TO 2PI SIG    9/73
R8   2  BASED ON ASSUMED ELASTICITY OF .46                                    9/73
R8 A          .007      .002           CORDEN    75 DBC      K- D 1.4-1.8GV/C  4/75
R8 A    CONSIDERABLE FRACTION OF THE SIGMA PI PI DECAY PROCEEDS VIA THE       4/75
R8 A    Y*1(1385) PI INTERMEDIATE STATE.                                      4/75
R8           . . . . . . . . . .
R8  AVG      0.00858   0.00054  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  STUDENT  0.00858   0.00059  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R8  FIT      0.00856   0.00054 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R9      Y*0(1520) TO Y*1(1385) PI TO LM PI PI/LM PI PI   (P8)/(P3)            9/73
R9         MORE THAN   0.10            CLINE     69 DBC      K-D TO 2PI LAM N  9/69
R9   B       0.39      0.10            BURKHARDT 71 HBC      LAM. 3PI PROD.    3/71
R9   C      (1.0)                      CHAN      72 IPWA     K-P TO LAM 2PI    2/73
R9   M       0.82      0.10            MAST      73 IPWA     K-P TO 2PI LAM   12/72
R9            .58       .22            CORDEN    75 DBC      K- D 1.4-1.8GV/C  4/75
R9   B  CENTRAL BIN(1514-1524) GIVES .74+-.10 -- OTHER BINS LOWER BY 2-5SIG
R9   C  CNLY THE Y*(1385)DS03 SEEMS TO CONTRIBUTE
R9   M  BOTH Y*(1385)DS03 AND SIGMA (PI PI)DP03 CONTRIBUTE
R9           . . . . . . . . . .
R9  AVERAGE MEANINGLESS (SCALE FACTOR = 2.2)

R10     Y*0(1520) INTO (Y*1(1385) PI)/TOTAL                  (P7)
R10          0.041     0.005           CHAN      72 HBC      K-P TO LAM 2PI    3/71

R11     Y*0(1520) INTO (LAMBDA PI PI)/TOTAL                  (P3)
R11          0.10     (0.02)           COLLEY    71 DBC      K-N 1.5 GEV PROD 10/71
R11  1        .11       .01            MAST      73 IPWA     K-P TO 2PI LAM    9/73
R11  1  BASED ON ASSUMED ELASTICITY OF .46+/-.02                              9/73
R11  3        .091      .006           CORDEN    75 DBC      K- D 1.4-1.8GV/C  4/75
R11  3  SUPERSEDES COLLEY 71                                                  1/76
R11          . . . . . . . . . .
R11 AVG      0.0960    0.0084   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
R11 STUDENT  0.0956    0.0062   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R11 FIT      0.0945    0.0043 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R12     Y*0(1520) INTO (LAMBDA EPSILON)/TOTAL                (P9)             4/75
R12           .20       .08            CORDEN    75 DBC      K- D 1.4-1.8GV/C  4/75

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Data Card Listings

For notation, see key at front of Listings.

Baryons

Λ(1520), Λ(1600), Λ(1670)

REFERENCES FOR Y*0(1520)


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GALTIERI 63 PL 6 296          A BARBARO-GALTIERI,A HUSSAIN,RD TRIPP (LRL)
WATSON   63 PR 131 2248       M B WATSON, M FERRO-LUZZI, R D TRIPP  (LRL)IJP
ALMEIDA  64 PL 9 204          S P ALMEIDA, G R LYNCH                (CERN)
ARMENTER 65 PL 19 338         ARMENTEROS,F-LUZZI, +    (CERN,HEID,SACLAY)
MUSGRAVE 65 NC 35 735         +PETMEZAS,+     (BIRM,CERN,EPOL,LOIC,SACLAY)

BIRMINGH 66 PR  152  1148     BIRMINGHAM,GLASGOW,I.C., OXFORD,RUTHERFORD
DAHL     67 PR 163 1377       DAHL,HARDY,HESS,KIRZ,MILLER            (LRL)
DAUBER   67 PL 24B 525        +MALAMUD,SCHLEIN,SLATER,STORK         (UCLA)
UHLIG    67 PR 155 1448       +CHARLTON,CONDON,GLASSER,YODH,+   (UMD,NRL)
MAST     68 PRL 21 1715       MAST,ALSTON,BANGERTER,GALTIERI+        (LRL)
SCHEUER  68 NP B8 503         SABRE COLLAB.     (SACL+AMST+BGNA+REHO+EPOL)

BURKHARD 69 NP B14 1C6        +FILTHUTH+KLUGE+..    (HEID+EFI+CERN+SACLAY)
CLINE    69 LNC 2 407         +LAUMANN+MAPP                         (WISC)
GALTIERI 69 LUND 352          BARBARO-GALTIERI,BANGERTER,MAST,TRIPP (LRL)
   ALSO  70 DUKE 95           R D TRIPP                              (LRL)

BURKHARDT71 NP  B27 64        +FILTHUTH,KLUGE,OBERLACK++ (HEID+CERN+SACL)
COLLEY   71 NP  B31 61        +COX,EASTWOOD,FRY+..  (BIRM+EDIN+GLAS+LOIC)
KIM      71 PRL 27 356        J K KIM                              (HARV)IJP
   ALSO  70 DUKE 161          J. K. KIM                            (HARV)IJP

CHAN     72 PRL 28 256        +BUT.-SHAFER,HERTZBACH,KOFLER++ (MASA,YALE)
MAST     73 PR D7 5           +ALSTON-GARNJOST,BANGERTER,+...       (LBL)IJP
MAST2    73 PRD 7 3212        +BANGERTER,ALSTON-GARNJOST,+          (LBL)IJP
BERTHON  74 NC 21A 146        BERTHON,TRISTRAM,+    (CDEF+RHEL+SACL+STRB)
CORDEN   75 NP B84 306        CORDEN,COX,DARTNELL,KENYON,ONEALE,+  (BIRM)

MAST     76 PRD 14 13         MAST,ALSTON-GARNJOST,BANGERTER+        (LBL)
CAMERON  77 NP B131 399       +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182        +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
   ALSO  77 PRL 38 1007       ALSTON-GARNJOST,KENNEY      (LBL+MTHO+CERN)IJP
BARLAG   79 NP B149 220       +BLOKZIJL,JONGEJANS+    (AMST+CERN+NIJM+OXF)

                              PAPERS NOT REFERRED TO IN DATA CARDS

BERLEY   70 PR D1 1996        +YAMIN,KOFLER,MANN,MEISNER+ (BNL,MASA,YALE)IJP
GOLOWICH 74 PRD 10 3861       EUGEN GOLOWICH                        (SLAC)
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Λ(1600) — P'_{01}

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101  Y*0(1600, JP=1/2+) I=0                                         1/76
SEE THE NOTE FOR THE Y*0(1800, JP=1/2+) P''01.
SOMEWHERE IN THIS REGION THERE IS PROBABLY ONE,
AND PERHAPS TWO, P01 STATES.

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                101  Y*0(1600) MASS (MEV)                            1/76

M   1     (1570.)                  KIM        71 DPWA   K-MATRIX ANAL.    1/76
M   1  POSSIBLE EFFECT IN SIGMA PI AND KBAR N CHANNELS.
M          1620.0     10.0         LANGBEIN   72 IPWA   MULTICHANNEL      1/76
M    2     1646.      7.           CARROLL    76 DPWA   I=0 TOTAL CS      2/77
M    3     1572. OR 1617.          MARTIN     77 DPWA   KBAR N MULTICHNL 11/77
M    3  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESCNANCE
M    3  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1573.      25.          RLIC       77 DPWA   KBAR N MULTICHNL  1/76
M          1703.      100.         ALSTON     78 DPWA   KBAR N ELASTIC    1/78
M          . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)

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                101  Y*0(1600) WIDTH (MEV)                           1/76

W   1       (50.)                  KIM        71 DPWA   K-MATRIX ANAL.    1/76
W           60.0      10.0         LANGBEIN   72 IPWA   MULTICHANNEL      1/76
W    2      (20.)                  CARROLL    76 DPWA   I=0 TOTAL CS      2/77
W    3      247. OR 271.           MARTIN     77 DPWA   KBAR N MULTICHNL 11/77
W           147.      50.          RLIC       77 DPWA   KBAR N MULTICHNL  1/76
W           593.      200.         ALSTON     78 DPWA   KBAR N ELASTIC    1/78
W           . . . . . . . . .
W   AVG     64.6      16.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
W   STUDENT 63.6      10.9     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
        SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                101  Y*0(1600) PARTIAL DECAY MODES                   1/76

                                                      DECAY MASSES
P1     Y*0(1600) INTO KBAR N                         497+ 939
P2     Y*0(1600) INTO SIGMA PI                      1197+ 139

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                101  Y*0(1600) BRANCHING RATIOS                      1/76

R1     Y*0(1600) INTO (KBAR N)/TOTAL                  (P1)                1/76
R1          0.25      0.15         LANGBEIN   72 IPWA   MULTICHANNEL      1/76
R1   2  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.04   SEEN BY CARROLL 76   2/77
R1   3      (.30)OR .29            MARTIN     77 DPWA   KBAR N MULTICHNL 11/77
R1           .24      .04          RLIC       77 DPWA   KBAR N MULTICHNL  1/76
R1           .14      .05          ALSTON     78 DPWA   KBAR N ELASTIC    1/78
R1          . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

R2     Y*0(1600) FROM KBAR N INTO SIGMA PI            SQRT(P1*P2)         1/76
R2          0.28      0.09         LANGBEIN   72 IPWA   MULTICHANNEL      1/76
R2        NOT SEEN                 HEPP2      76 DPWA -0 K- NUC TO SIG PI 2/77
R2   3     (-.39)OR -.39           MARTIN     77 DPWA   KBAR N MULTICHNL 11/77
R2          -.16      .04          RLIC       77 DPWA   KBAR N MULTICHNL  1/76
R2          . . . . . . . . .
R2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

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REFERENCES FOR Y*0(1600)


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KIM      71 PRL 27 356        J K KIM                              (HARV)IJP
   ALSO  70 DUKE 161          J. K. KIM                            (HARV)IJP

LANGBEIN 72 NP B47 477        +WAGNER                              (MPIM)IJP

CARROLL  76 PRL 37 806        +CHIANG,KYCIA,LI,MAZUR,MICHAEL+       (BNL)I
HEPP2    76 PL 65B 487        +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)IJP
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REFERENCES FOR Y*0(1520) (continued)


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MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
   ALSO  77 NP B126 266       MARTIN,PIDCCCK                       (LOUC)
   ALSO  77 NP B126 285       MARTIN,PIDCOCK                       (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182        +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
   ALSO  77 PRL /38 1007      ALSTON-GARNJOST,KENNEY      (LBL+MTHO+CERN)IJP
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Λ(1670) — S''_{01}

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40  Y*0(1670, JP=1/2-) I=0
SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

 THIS RESONANCE IS WELL ESTABLISHED.

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                40  Y*0(1670) MASS (MEV)

M   M     (1666.0)OR(1675.0)       BERLEY    65 HBC   0 K-P TO LAM ETA    7/66
M   M   THE FIRST VALUE ASSUMES THE BRANCHING RATIO INTO LAMBDA ETA IS
M     SMALL, THE SECOND THAT IT IS LARGE.  BECAUSE THE RESONANCE IS NEAR
M     THE LAMBDA ETA THRESHOLD, THE BRANCHING RATIO AFFECTS THE MOMENTUM
M     DEPENDENCE OF THE TOTAL WIDTH, AND THUS ALSO THE RESONANCE PARA-
M     METERS OBTAINED BY FITTING TO THE DATA.
M    N    (1663.0)    (3.0)        ARMENT-1  68 HBC   0 ELASTIC, CH EXCH 11/68
M    N    (1678.0)    (2.0)        ARMENT-2  68 HBC   0 K-P TO SIGMA PI  11/68
M    A     1674.0     (5.0)        ARMENT-3  69 HBC   0 MULTICHANNEL      9/69
M    N     1662.0     (3.0)        ARMENT-4  69 HBC   0 ELAST,CH.EXC.ED   9/69
M    N     1680.0     (1.0)        ARMENT-4  69 HBC   0 K-P TO SIG PI.ED  9/69
M          1674.0                  BERLEY    69 HBC   0 K-P TO SIGMA PI   6/70
M          1683.0     (5.0)        GALTIERI  70 HBC   0 SIG PI,EDPWA      7/70
M          1670.                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
M          1640.0    (40.0)        LANGBEIN  72 IPWA    MULTICHANNEL    .12/72
M          1700.     (10.)         BAXTER    73 DPWA  0 K- P TO NEUTRALS 10/74
M          1672.      (1.)         HART      73 DPWA    EL+CX,.7-.8GEV/C  2/74
M          1665.      (5.)         PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
M          1675.      (2.)         HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
M    2    (1664.)                  MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    2  MARTIN 77 OBTAINS IDENTICAL RESONANCE PARAMETERS FROM THE
M    2  T-MATRIX POLE AND FROM A B-W FIT.
M          1670.      (5.)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          1671.      (3.)         ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M    A          THE MULTICHANNEL ANALYSIS INCLUDES ELASTIC AND SIGMA PI .  10/69
M    N   THE APPARENT DISCREPANCY BETWEEN THESE RESULTS IS PROBABLY NCT
M     SERIOUS.  THE ERRORS GIVEN ARE JUST STATISTICAL.  THE SYSTEMATIC
M     ERRORS THAT RESULT FROM THE RESTRICTIVE PARAMETRIZATION FORCED ON
M     THE PARTIAL-WAVE AMPLITUDES ARE NOT INCLUDED, AND CAN BE LARGE.

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                40  Y*0(1670) WIDTH (MEV)

W   M       (22.0)OR(15.0)         BERLEY    65 HBC   0 SEE NOTE M ABOVE  7/66
W    N      (26.0)    (8.0)        ARMENT-1  68 HBC   0 SEE NOTE N ABOVE 11/68
W    N      (26.0)    (5.0)        ARMENT-2  68 HBC   0                  11/68
W    A       23.0     (3.0)        ARMENT-3  69 HBC   0                   9/69
W    N       38.0    (15.0)        ARMENT-4  69 HBC   0 ELAST,CH EXC.ED   9/69
W    N       33.0     (5.0)        ARMENT-4  69 HBC   0 K-P TO SIG PI.ED  9/69
W            31.0                  BERLEY    69 HBC   0 K-P TO SIGMA PI   6/70
W            25.0     (5.0)        GALTIERI  70 HBC   0 SIG PI,EDPWA      7/70
W            35.                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
W            45.0    (20.0)        LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W            65.     (20.)         BAXTER    73 DPWA  0 K- P TO NEUTRALS 10/74
W            19.      (2.)         HART      73 DPWA    EL+CX,.7-.8GEV/C  2/74
W            19.      (5.)         PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
W            46.      (5.)         HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
W    2      (12.)                  MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W            45.     (10.)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W            29.      (5.)         ALSTON    78 DPWA    KBAR N ELASTIC    1/78
          SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                40  Y*0(1670) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1     Y*0(1670) INTO KBAR N                         497+ 939
P2     Y*0(1670) INTO LAMBDA ETA                    1115+ 548
P3     Y*0(1670) INTO SIGMA PI                      1189+ 139
P4     Y*0(1670) INTO SIGMA(1385) PI                 139+1384

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                40  Y*0(1670) BRANCHING RATIOS

R1     Y*0(1670) INTO (KBAR N)/TOTAL                   (P1)
R1   P      (0.14)    (0.04)       ARMENT-1  68 HBC   0 OLD DATA         11/68
R1           0.17                  ARMENT-3  69 HBC   0                   9/69
R1   P       0.14     (0.04)       ARMENT-4  69 HBC   0 NEW DATA          9/69
R1   A      (0.39)    (0.05)       CONFORTO  71 HBC   0 K-P,ELAST,CEX     6/70
R1           0.28                  KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1           0.35     (0.06)       LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1            .36     (.03)        HART      73 DPWA    EL+CX,.7-.8GEV/C  2/74
R1   2      (.15)                  MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1            .20     (.03)        RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1            .17     (.03)        ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1   A    EFFECT BELOW REGION ANALYZED. VALUE OF .18 DOES NOT
R1   A  AFFECT FIT OR VALUES OF OTHER PARAMETERS.
R1   P   THIS IS THE DIAMETER OF THE CIRCLE IN THE ARGAND PLOT.  IT IS
R1     SUPERIMPOSED ON A LARGE BACKGROUND.

R2     Y*0(1670) FROM KBAR N TO LAMBDA ETA             SQRT(P1*P2)
R2   M      (0.20) OR 0.23         BERLEY    65 HBC   0 SEE NOTE M ABOVE  7/66
R2          (0.26)                 ARMENT-3  69 HBC   0                   9/69
R2          (0.24)                 KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2           +.20     (.05)        BAXTER    73 DPWA  0 K- P TO NEUTRALS 10/74
      SEE THE NOTES ACCOMPANYING MASSES QUOTED

R3     Y*0(1670) FROM KBAR N TO SIGMA PI               SQRT(P1*P3)
R3  1       (-0.25)   (0.06)       ARMENT-2  68 HBC   0 OLD DATA
R3  1       (-0.27)                ARMENT-3  69 HBC   0                   9/69
R3  1       (-0.30)   (0.03)       ARMENT-4  69 HBC   0 NEW DATA          9/69
R3  1  PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT) 10/74
R3           -0.27                 BERLEY    69 HBC   0 K-P TO SIGMA PI   6/70
R3           -0.29    (0.03)       GALTIERI  70 HBC   0 SIG PI,EDPWA      7/70
R3           -0.38                 KIM       71 DPWA    K-MATRIX ANAL.    3/71
R3            -.28    (.05)        BAXTER    73 DPWA  0 K- P TO NEUTRALS 10/74
R3            -.23    (.03)        LONDON    75 HLBC  0 K- P TO SIGO PIO  4/75
R3            -.29    (.03)        HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
R3   2       (-.13)                MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R3            -.31    (.03)        RLIC      77 DPWA    KBAR N MULTICHNL  1/76
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Baryons
$\Lambda(1670)$, $\Lambda(1690)$, $\Lambda(1800)$

Data Card Listings
For notation, see key at front of Listings.

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R4     Y*0(1670) FROM KBAR N TO SIGMA(1385) PI              SQRT(P1*P4)
R4              -.18      .05               PREVOST    74 DPWA 0- K-N TO S(1385)PI 10/74

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                                REFERENCES FOR Y*0(1670)

BERLEY    65 PRL 15 641          +CONNOLLY, HART, RAUM, STONEHILL, +    (BNL)IJP
ARMENT-1 68 NP B8 195            ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-2 68 NP B8 223            ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP

ARMENT-3 69 LUND PAPER 229       ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
    VALUES ARE QUOTED IN LEVI SETTI 69.
ARMENT-4 69 NP B14 91            ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BERLEY    69 PL 30B 430          + HART, RAHM, WILLIS, YAMAMOTO          (BNL)IJP
GALTIERI 70 DUKE 173             A. BARBARO GALTIERI                     (LRL)IJP

CONFORTO 71 NP  B34  41          +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM       71 PRL 27 356          J K KIM                                (HARV)IJP
    ALSO 70 DUKE 161             J. K. KIM                              (HARV)IJP
LANGBEIN 72 NP B47 477           +WAGNER                                (MPIM)IJP
BAXTER    73 NP B67 125          BAXTER,BUCKINGHAM,CORBETT,DUNN,+    (OXFORD)IJP
HART      73 PURDUE CONF. 311    +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
PREVOST   74 NP B69 246          PREVOST,BARLOUTAUD,+         (SACL+CERN+HEID)
LONDON    75 NP B85 289          LONDON,YU,BOYD,+  (BNL,CERN,EPOL,ORSA,TORI)

HEPP2     76 PL 65B 487          +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)IJP
MARTIN    77 NP B127 349         MARTIN,PIDCOCK,MOORHOUSE           (LOUC+GLAS)IJP
    ALSO 77 NP B126 266          MARTIN,PIDCOCK                          (LOUC)
    ALSO 77 NP B126 285          MARTIN,PIDCOCK                          (LOUC)IJP
RLIC      77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RFEL)IJP
ALSTON    78 PR D18 182          +KENNEY,POLLARD,ROSS+          (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007          ALSTON-GARNJOST,KENNEY         (LBL+MTHO+CERN)IJP

                                 PAPERS NOT REFERRED TO IN DATA CARDS

BIRMINGH 66 PR 152 1148            (BIRMINGHAM,GLASGOW,LOIC,OXFORD,RUTHERFD)
LEVISETT 69 LUND 339             R LEVI SETTI  (RAPPORTEUR)          (CHICAGO)

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$\Lambda(1690)$ — D''_{03}

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          55   Y*0(1690, JP=3/2-) I=0

          SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

          THIS RESONANCE IS WELL ESTABLISHED.

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                    55   Y*0(1690) MASS (MEV)

M         (1696.0)     (3.0)          ARMENT-1  68 HBC    0 ELASTIC, CH EXCH 11/68
M         (1681.0)     (2.0)          ARMENT-3  68 HBC    0 K-P TO SIGMA PI  11/68
M          1681.       (8.)           BARTLEY   68 DBC    0 K-P AND K-D DATA 11/68
M          1695.0      (4.0)          BUGG      68 CNTR   0 K-P, D TOTAL      7/68
M    M    (1657.0)     (2.0)          CONFORTO  68 HBC    0 ELASTIC, CH EXCH 11/68
M    M    THE Y*0(1690) IS AT THE EDGE OF THE ENERGY REGION ANALYZED BY
M    M   CONFORTO. THE SAME DATA AS WELL AS OTHERS EXTENDING TO LOWER
M    M   ENERGIES ARE INCLUDED IN ARMENTEROS 1.
M     A    1691.0      (2.0)          ARMENT-4  69 HBC    0 ELAS,CH EXC.ED    9/69
M     A   ANALYSIS INCLUDES OLD AND NEW DATA OF CHS COLLAB.  .43-.8 GEV/C
M     A   THE APPARENT DISCREPANCY BETWEEN THE SIGMA PI AND OTHER RESULTS IS
M     A PROBABLY NOT SERIOUS.  THE ERRORS GIVEN ARE JUST STATISTICAL.  THE
M     A SYSTEMATIC ERRORS THAT RESULT FROM THE RESTRICTIVE PARAMETRIZATION
M     A OF THE PARTIAL-WAVE AMPLITUDES ARE NOT INCLUDED, AND CAN BE LARGE.
M     A    1688.0      (2.0)          ARMENT-4  69 HBC    0 K-P TO SIG PI.ED  9/69
M          1689.0                     BERLEY    69 HBC    0 K-P TO SIGMA PI   6/70
M          1701.0      (4.0)          BERTANZA  69 HBC    0 ELASTIC, CH EXCH  9/69
M          1680.0      (5.0)          GALTIERI  70 HBC    0 SIG PI,EDPWA      7/70
M          1688.0      (3.0)          CONFORTO  71 HBC    0 K-P,ELAST,CEX     6/70
M          1690.                      KIM       71 DPWA     K-MATRIX ANAL.    3/71
M          1680.0     (20.0)          LANGBEIN  72 IPWA     MULTICHANNEL     12/72
M          1670.      (10.)           BAXTER    73 DPWA   0 K- P TO NEUTRALS 10/74
M          1684.       (3.)           HART      73 DPWA     EL+CX,.7-.8GEV/C  2/74
M     2    1692.       (4.)           CARROLL   76 DPWA     I=0 TOTAL CS      2/77
M          1690.       (3.)           HEPP2     76 DPWA -0 K- NUC TO SIG PI   2/77
M     3    1687. OR 1689.             MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
M     3  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     3  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M     3  ANOTHER 3/2- LAMBDA AT 1966 MEV IS ALSO SUGGESTED BY MARTIN77,
M     3  BUT IS VERY UNCERTAIN.
M          1690.       (5.)           RLIC      77 DPWA     KBAR N MULTICHNL  1/76
M          1692.       (5.)           ALSTON    78 DPWA     KBAR N ELASTIC    1/78

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                    55   Y*0(1690) WIDTH (MEV)

W           (35.0)     (7.0)          ARMENT-1  68 HBC    0 OLD DATA         11/68
W           (85.0)     (7.0)          ARMENT-3  68 HBC    0 OLD DATA         11/68
W             48.     (15.)           BARTLEY   68 DBC    0 K-P AND K-D DATA 11/68
W             40.0     (7.0)          BUGG      68 CNTR   0                   7/68
W    M      (27.0)     (5.0)          CONFORTO  68 HBC    0 SEE NOTE M ABOVE 11/68
W     A       31.0     (7.0)          ARMENT-4  69 HBC    0 ELAS,CH EXC.ED    9/69
W     A       72.0     (6.0)          ARMENT-4  69 HBC    0 K-P TO SIG PI ED  9/69
W             57.0                    BERLEY    69 HBC    0 K-P TO SIGMA PI   6/70
W             28.0     (8.0)          BERTANZA  69 HBC    0                   9/69
W             85.0    (10.0)          GALTIERI  70 HBC    0 SIG PI,EDPWA      7/70
W             64.0     (5.0)          CONFORTO  71 HBC    0 K-P,ELAST,CEX     6/70
W             55.                     KIM       71 DPWA     K-MATRIX ANAL.    3/71
W             40.0    (10.0)          LANGBEIN  72 IPWA     MULTICHANNEL     12/72
W             30.     (10.)           BAXTER    73 DPWA   0 K- P TO NEUTRALS 10/74
W             86.      (9.)           HART      73 DPWA     EL+CX,.7-.8GEV/C  2/74
W     2     (38.)                     CARROLL   76 DPWA     I=0 TOTAL CS      2/77
W             82.      (8.)           HEPP2     76 DPWA -0 K- NUC TO SIG PI   2/77
W     3       62. OR 62.              MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
W             60.      (5.)           RLIC      77 DPWA     KBAR N MULTICHNL  1/76
W             64.     (10.)           ALSTON    78 DPWA     KBAR N ELASTIC    1/78
            SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                    55   Y*0(1690) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1     Y*0(1690) INTO KBAR N                            497+ 939
P2     Y*0(1690) INTO SIGMA PI                         1189+ 139
P3     Y*0(1690) INTO LAMBDA PI PI                     1115+ 139+ 139
P4     Y*0(1690) INTO SIGMA PI PI                      1189+ 139+ 139
P5     Y*0(1690) INTO Y*1(1385) PI S-WAVE               139+1384
P6     Y*0(1690) INTO LAMBDA ETA                       1115+ 548

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                    55   Y*0(1690) BRANCHING RATIOS

   THE SUM OF ALL THE QUOTED BRANCHING RATIOS IS MORE THAN 1.0.  THE
   TWO-BODY RATIOS ARE FROM PARTIAL WAVE ANALYSES, AND THUS PROBABLY ARE
   MORE RELIABLE THAN THE THREE-BODY RATIOS, WHICH ARE DETERMINED FROM
   BUMPS IN CROSS SECTIONS.  OF THE LATTER, THE SIGMA PI PI BUMP LOOKS
   MORE SIGNIFICANT (THE ERROR GIVEN FOR THE LAMBDA PI PI RATIO LOOKS UN-
   REASONABLY SMALL).  HARDLY ANY OF THE SIGMA PI PI DECAY CAN BE VIA
   Y*1(1385), FOR THEN NINE TIMES AS MUCH LAMBDA PI PI DECAY WOULD BE
   REQUIRED.

R1     Y*0(1690) INTO (KBAR N)/TOTAL                          (P1)
R1          (0.18)    (0.03)          ARMENT-1  68 HBC    0                  11/68
R1          (0.23)                    BUGG      68 CNTR   0 ASSUMING J=3/2    7/68
R1   M      (0.22)    (0.03)          CONFORTO  68 HBC    0 SEE NOTE M ABOVE 11/68
R1           0.18     (0.02)          ARMENT-4  69 HBC    0 NEW DATA          9/69
R1           0.28     (0.04)          BERTANZA  69 HBC    0                   9/69
R1   N      (0.34)    (0.02)          CONFORTO  71 HBC    0 K-P,ELAST,CEX     6/70
R1           0.22                     KIM       71 DPWA     K-MATRIX ANAL.    3/71
R1           0.15     (0.05)          LANGBEIN  72 IPWA     MULTICHANNEL     12/72
R1            .24      (.01)          HART      73 DPWA     EL+CX,.7-.8GEV/C  2/74
R1    3     (.28)OR .26               MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
R1            .24      (.03)          RLIC      77 DPWA     KBAR N MULTICHNL  1/76
R1            .22      (.03)          ALSTON    78 DPWA     KBAR N ELASTIC    1/78
R1    2  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.48    SEEN BY CARROLL 76     2/77
R1   N  EFFECT IS AT END OF REGION ANALYZED. THIS COULD AFFECT VALUE OF X1.

R2     Y*0(1690) FROM KBAR N TO SIGMA PI                    SQRT(P1*P2)
R2   1     (-0.33)    (0.02)          ARMENT-3  68 HBC    0 OLD DATA         11/68
R2   1     (-0.36)    (0.02)          ARMENT-4  69 HBC    0 NEW DATA          9/69
R2   1  PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT) 10/74
R2          -0.27                     BERLEY    69 HBC    0 K-P TO SIGMA PI   6/70
R2          -0.31     (0.03)          GALTIERI  70 HBC    0 SIG PI,EDPWA      7/70
R2          -0.40                     KIM       71 DPWA     K-MATRIX ANAL.    3/71
R2           0.26     (0.07)          LANGBEIN  72 IPWA     MULTICHANNEL     12/72
R2           -.20      (.03)          BAXTER    73 DPWA   0 K- P TO NEUTRALS 10/74
R2           -.28      (.03)          LONDON    75 HLBC   0 K- P TO SIGO PIO  4/75
R2           -.29      (.03)          HEPP2     76 DPWA -0 K- NUC TO SIG PI   2/77
R2    3    (-.30)OR -.28              MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
R2           -.25      (.03)          RLIC      77 DPWA     KBAR N MULTICHNL  1/76

R3     Y*0(1690) FROM KBAR N TO LAMBDA PI PI                SQRT(P1*P3)
R3   B      (0.25)    (0.02)          BARTLEY   68 HDBC   0 LAM 2PI CROS SEC 11/68
R3   B   ONLY CROSS-SECTION DATA USED. ENHANCEMENT NOT SEEN BY PREVOST 71,    3/72

R4     Y*0(1690) FROM KBAR N TO SIGMA PI PI                 SQRT(P1*P4)
R4          (0.21)                    ARMENT-2  68 HDBC   0 K-N TO SIG PI PI 11/68

R5     Y*0(1690) FROM KBAR N INTO LAMBDA ETA                SQRT(P1*P6)
R5            .00      (.03)          BAXTER    73 DPWA   0 K- P TO NEUTRALS 10/74

R6     Y*0(1690) FROM KBAR N TO Y*1(1385) PI S-WAVE         SQRT(P1*P5)
R6           +.27      .04            PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74

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                                REFERENCES FOR Y*0(1690)

ARMENT-1 68 NP B8 195            ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-2 68 NP B8 216            ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY) I
ARMENT-3 68 NP B8 223            ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BARTLEY   68 PRL 21 1111         +CHU,DOWD,GREENE,+      (TUFTS,FSU,BRANDEIS) I
BUGG      68 PR 168 1466         +GILMORE, KNIGHT, +          (BIRM,CAVE,RHEL) I
    ALSO 67 PRL 18 62            DAVIES,DOWELL,+              (BIRM,CAVE,RHEL) I
CONFORTO 68 NP B8 265            +HARMSEN, LASINSKI, +      (CHICAGO,HEIDEL)IJP

ARMENT-4 69 NP B14 91            ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BERLEY    69 PL 30B 430          + HART, RAHM, WILLIS, YAMAMOTO          (BNL)IJP
BERTANZA 69 PR 177 2036          +BIGI,CARRARA,CASALI, +       (PISA,BNL,YALE)IJP

GALTIERI 70 DUKE 173             A. BARBARO GALTIERI                     (LRL)IJP
CONFORTO 71 NP  B34  41          +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM       71 PRL 27 356          J K KIM                                (HARV)IJP
    ALSO 70 DUKE 161             J. K. KIM                              (HARV)IJP
LANGBEIN 72 NP B47 477           +WAGNER                                (MPIM)IJP
BAXTER    73 NP B67 125          BAXTER,BUCKINGHAM,CORBETT,DUNN,+    (OXFORD)IJP
HART      73 PURDUE CONF. 311    +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
PREVOST   74 NP B69 246          PREVOST,BARLOUTAUD,+         (SACL+CERN+HEID)

LONDON    75 NP B85 289          LONDON,YU,BOYD,+  (BNL,CERN,EPCL,ORSA,TCRI)
CARROLL   76 PRL 37 806          +CHIANG,KYCIA,LI,MAZUR,MICHAEL+         (BNL)I
HEPP2     76 PL 65B 487          +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)IJP

MARTIN    77 NP B127 349         MARTIN,PIDCOCK,MOORHOUSE           (LOUC+GLAS)IJP
    ALSO 77 NP B126 266          MARTIN,PIDCOCK                          (LOUC)
    ALSO 77 NP B126 285          MARTIN,PIDCOCK                          (LOUC)IJP
RLIC      77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RFEL)IJP
ALSTON    78 PR D18 182          +KENNEY,POLLARD,ROSS+          (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007          ALSTON-GARNJOST,KENNEY         (LBL+MTHO+CERN)IJP

                                 PAPERS NOT REFERRED TO IN DATA CARDS

PREVOST   71  AMSTERDAM CONF     + CHS COLLABORATION          (CERN+HEID+SACL)

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$\Lambda(1800)$ — S'''_{01}

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          36   Y*0(1800, JP=1/2-) I=0

          THE S01 AMPLITUDE SHOWS A RATHER CLEAR SECOND RESONANCE
          BEHAVIOR IN THE 1700-1900 MEV REGION.  THERE ARE WIDE
          DISAGREEMENTS AMONG THE MASS, WIDTH, AND COUPLING
          DETERMINATIONS.

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                    36   Y*0(1800) MASS (MEV)

M         (1872.0)    (10.0)          BRICMAN   70 DPWA     TOT, ELAS, CHEX   1/71
M         (1780.)                     KIM       71 DPWA     K-MATRIX ANAL.    3/71
M          1830.0     (20.0)          LANGBEIN  72 IPWA     MULTICHANNEL     12/72
M    1     1767. OR 1842.             MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
M    1  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    1  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1825.      (20.)           RLIC      77 DPWA     KBAR N MULTICHNL  1/76
M          1725.      (20.)           ALSTON    78 DPWA     KBAR N ELASTIC    1/78

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Data Card Listings
For notation, see key at front of Listings.

Baryons
Λ(1800)

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                    36  Y*0(1800) WIDTH (MEV)

W          (100.0)   (20.0)          BRICMAN   70 DPWA    TOT, ELAS, CHEX    1/71
W          (40.)                     KIM       71 DPWA    K-MATRIX ANAL.     3/71
W           70.0     (15.0)          LANGBEIN  72 IPWA    MULTICHANNEL      12/72
W    1     435. OR 473.              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W          230.      (20.)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W          185.      (20.)           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
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                    36  Y*0(1800) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     Y*0(1800) INTO KBAR N                                  497+ 939
P2     Y*0(1800) INTO SIGMA PI                               1197+ 139
P3     Y*0(1800) INTO Y*1(1385) PI                            139+1384
P4     Y*0(1800) INTO N K*(890), S1 WAVE                      939+ 892
P5     Y*0(1800) INTO N K*(890), D3 WAVE                      939+ 892
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                    36  Y*0(1800) BRANCHING RATIOS

R1     Y*0(1800) INTO (KBAR N)/TOTAL                        (P1)
R1          (0.18)   (0.02)          BRICMAN   70 DPWA    TOT, ELAS, CHEX    1/71
R1          (0.80)                   KIM       71 DPWA    K-MATRIX ANAL.     3/71
R1           0.35    (0.15)          LANGBEIN  72 IPWA    MULTICHANNEL      12/72
R1   1      (1.21)OR .70             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1            .37     (.05)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1            .28     (.05)          ALSTON    78 DPWA    KBAR N ELASTIC    1/78

R2     Y*0(1800) FROM KBAR N TO SIGMA PI                    SQRT(P1*P2)
R2          (0.24)                   KIM       71 DPWA    K-MATRIX ANAL.     3/71
R2   1      (-.74)OR -.43            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2           -.08     (.05)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3     Y*0(1800) FROM KBAR N INTO Y*1(1385) PI              SQRT(P1*P3)
R3   2        +.056     .028         CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R3   2  SIGN CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.      12/79*

R4     Y*0(1800) FROM KBAR N INTO N K*(890), S1 WAVE        SQRT(P1*P4)
R4   3       -0.17      0.03         CAMERON2  78 DPWA    K-P TO K*N        12/79*
R4   3  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST      12/79*
R4   3  CONVENTION.                                                         12/79*

R5     Y*0(1800) FROM KBAR N INTO N K*(890), D3 WAVE        SQRT(P1*P5)
R5           -0.13      0.04         CAMERON2  78 DPWA    K-P TO K*N        12/79*
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                    REFERENCES FOR Y*0(1800)

BRICMAN  70 PL 33B 511       C BRICMAN, M FERRO-LUZZI, J P LAGNAUX(CERN)IJP
KIM      71 PRL 27 356       J K KIM                              (HARV)IJP
   ALSO  70 DUKE 161         J. K. KIM                            (HARV)IJP
LANGBEIN 72 NP B47 477       +WAGNER                              (MPIM)IJP

MARTIN   77 NP B127 349      MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
   ALSO  77 NP B126 266      MARTIN,PIDCOCK                       (LOUC)
   ALSO  77 NP B126 285      MARTIN,PIDCOCK                       (LOUC)IJP
RLIC     77 NP B119 362      GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182       +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
   ALSO  77 PRL 38 1007      ALSTON-GARNJOST,KENNEY       (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189      +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327      +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP

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Λ(1800)   77 Y*0(1800, JP=1/2+) I=0   **P''_{01}**

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SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THE EVIDENCE FOR THIS STATE IS SOMEWHAT CONFUSED.  IT
WAS FIRST SUGGESTED IN A PARTIAL WAVE ANALYSIS OF
KBAR N DATA BY THE BEHAVIOUR OF THE P01 AMPLITUDE
WHEN IT WAS PARAMETRIZED AS A TWO-STRAIGHT-LINE
BACKGROUND (ARMENTEROS 68).

   ALMOST ALL THE RECENT ANALYSES CONTAIN A P01 STATE, AND SOMETIMES
   TWO, BUT THE MASSES, WIDTHS, AND BRANCHING RATIOS OBTAINED IN THE
   DIFFERENT ANALYSES VARY GREATLY.  SEE ALSO THE Y*0(1600)P01 LISTING.
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                    77  Y*0(1800) MASS (MEV)

M          (1745.0)                  ARMENTERO 68 HBC   O ELASTIC, CH EXCH 11/68
M          (1740.0)                  BAILEY    69 DPWA  O ELASTIC, CH EXCH 10/70
M          (1800.0)                  ARMENTERO 70 HBC   O ELASTIC, CH EX    6/70
M          (1750.0)                  ARMENTERO 70 HBC   O SIGMA PI          6/70
M    N     (1690.0)   (10.0)         GALTIERI  70 HBC   O SIG PI,EDPWA      7/70
M    N   ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED  1/71
M          (1755.)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
M           1780.0     20.0          LANGBEIN  72 IPWA    MULTICHANNEL     12/72
M           1746.      10.           PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
M    1      1735.       5.           CARROLL   76 DPWA    I=0 TOTAL CS      2/77
M    3      1861. OR 1953.           MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    3   THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    3   PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M           1853.      20.           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M           . . . . . . . . .
M      AVERAGE MEANINGLESS (SCALE FACTOR = 3.5)
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                    77  Y*0(1800) WIDTH (MEV)

W          (147.0)                   ARMENTERO 68 HBC   O
W          (300.0)                   BAILEY    69 DPWA  O ELASTIC, CH EXCH 10/70
W           (30.0)                   ARMENTERO 70 HBC   O ELASTIC, CH EX    6/70
W           (70.0)                   ARMENTERO 70 HBC   O SIGMA PI          6/70
W    N      (22.0)                   GALTIERI  70 HBC   O SIG PI,EDPWA      7/70
W           (35.)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
W           120.0      10.0          LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W            46.       20.           PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
W    1      (28.)                    CARROLL   76 DPWA    I=0 TOTAL CS      2/77
W    3      535. OR 585.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W           166.       20.           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W            90.0      20.0          CAMERON2  78 DPWA    K-P TO K*(890) N 12/79*
W           . . . . . . . . .
W      AVERAGE MEANINGLESS (SCALE FACTOR = 2.6)
          SEE THE NOTES ACCOMPANYING MASSES QUOTED
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                    77  Y*0(1800) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     Y*0(1800) INTO KBAR N                                  497+ 939
P2     Y*0(1800) INTO SIGMA PI                               1197+ 139
P3     Y*0(1800) INTO SIGMA(1385) PI                          139+1384
P4     Y*0(1800) INTO N K*(890), P1 WAVE                      939+ 892
P5     Y*0(1800) INTO N K*(890), P3 WAVE                      939+ 892
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                    77  Y*0(1800) BRANCHING RATIOS

R1     Y*0(1800) INTO (KBAR N)/TOTAL                        (P1)
R1          (0.4)                    ARMENTERO 68 DPWA  O ELASTIC, CH EXCH 11/68
R1          (0.55)                   BAILEY    69 DPWA  O ELASTIC, CH EXCH 10/70
R1          (0.15)                   ARMENTERO 70 DPWA  O ELASTIC, CH EXCH 10/70
R1          (0.30)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1           0.36      0.05          LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1   3      (.52)OR .49              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1            .21       .04          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1   1  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.29   SEEN BY CARROLL 76     2/77
R1          . . . . . . . . .
R1     AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)

R2     Y*0(1800) FROM KBAR N INTO SIGMA PI                  SQRT(P1*P2)
R2   2      (+0.20)                  ARMENTERO 70 DPWA  O K-P TO SIGMA PI   6/70
R2   2  PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT) 10/74
R2   N      (-0.13)   (0.03)         GALTIERI  70 DPWA  O K-P TO SIGMA PI   7/70
R2          (0.17)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2          (0.01) OR LESS           LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R2   3      (+.25)OR +.23            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2           -.24       .04          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3     Y*0(1800) FROM KBAR N TO SIGMA(1385) PI              SQRT(P1*P3)
R3            +.18      .10          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74

R4     Y*0(1800) FROM KBAR N INTO N K*(890), P1 WAVE        SQRT(P1*P4)
R4   4       -0.14      0.03         CAMERON2  78 DPWA    K-P TO K*N       12/79*
R4   4  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST     12/79*
R4   4  CONVENTION.                                                        12/79*

R5     Y*0(1800) FROM KBAR N INTO N K*(890), P3 WAVE        SQRT(P1*P5)
R5            +.35      0.06         CAMERON2  78 DPWA    K-P TO K*N       12/79*

          SEE THE NOTES ACCOMPANYING MASSES QUOTED
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                    REFERENCES FOR Y*0(1800)

ARMENTER 68 NP B8 195        ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BAILEY   69 THESIS UCRL-50617 DAVID SAAL BAILEY          (LRL LIVERMORE)IJP
ARMENTER 70 DUKE CONF 123    ARMENTEROS, BAILLON, +        (CERN, HEIDEL)IJP
GALTIERI 70 DUKE CONF 173    A BARBARO-GALTIERI                    (LRL)IJP
KIM      71 PRL 27 356       J K KIM                              (HARV)IJP
   ALSO  70 DUKE 161         J. K. KIM                            (HARV)IJP
LANGBEIN 72 NP B47 477       +WAGNER                              (MPIM)IJP

PREVOST  74 NP B69 246       PREVOST,BARLOUTAUD,+          (SACL+CERN+HEID)
CARROLL  76 PRL 37 806       +CHIANG,KYCIA,LI,MAZUR,MICHAEL+         (BNL)I
MARTIN   77 NP B127 349      MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
   ALSO  77 NP B126 266      MARTIN,PIDCOCK                       (LOUC)
   ALSO  77 NP B126 285      MARTIN,PIDCOCK                       (LOUC)IJP
RLIC     77 NP B119 362      GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
CAMERON2 78 NP B146 327      +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP

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Λ(1800)   102 Y*0(1800, JP=9/2-) I=0   **G_{09}**   1/76

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THIS NARROW RESONANCE SEEMS NECESSARY TO FIT A PEAK
IN THE A7 COEFFICIENT OF THE K-P ANGULAR DISTRIBUTION.
IT IS NOT REQUIRED IN ANY OTHER CHANNEL.
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                    102  Y*0(1800) MASS (MEV)                             1/76

M          1808.       5.            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
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                    102  Y*0(1800) WIDTH (MEV)                            1/76

W           27.        5.            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
------ --------- --------- --------- --------- --------- --------- --------

                    102  Y*0(1800) PARTIAL DECAY MODES                    1/76

                                                              DECAY MASSES
P1     Y*0(1800) INTO KBAR N                                  497+ 939
P2     Y*0(1800) INTO SIGMA PI                               1197+ 139
------ --------- --------- --------- --------- --------- --------- --------

                    102  Y*0(1800) BRANCHING RATIOS                       1/76

R1     Y*0(1800) INTO (KBAR N)/TOTAL                        (P1)            1/76
R1            .04       .01          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R2     Y*0(1800) FROM KBAR N INTO SIGMA PI                  SQRT(P1*P2)     1/76
R2          LESS THAN .04            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
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                    REFERENCES FOR Y*0(1800)

RLIC     77 NP B119 362      GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP

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Baryons
Λ(1800), Λ(1815)

Data Card Listings
For notation, see key at front of Listings.

Λ(1800) BUMPS

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119  Y*0(1800, JP=      ) I=?          PRODUCTION EXPERIMENTS

LOCKMAN 78 OBSERVE A 5 STD. DEV. ENHANCEMENT IN THE
LAMBDA PI+ PI- MASS SPECTRUM FROM THE REACTION
PP --> LAMBDA PI+ PI- + ANYTHING IN A CERN ISR
EXPERIMENT AT C.M. ENERGIES OF 43 AND 62 GEV.
THE MAIN DECAY MODES APPEAR TO BE Y*1(1385) PI AND
Y*1(1560) PI (SEE THE ENTRY FOR Y*1(1560)).
THE I-SPIN IS NOT ESTABLISHED, BUT SINCE THE LAMBDA PI DECAY IS NOT
OBSERVED, I=0 IS MARGINALLY PREFERRED.

            119  Y*0(1800) MASS  (MEV) (PROD. EXP.)

M       60 1802.       3.              LOCKMAN    78 SPEC  0 PP TO L PI PI X  12/79*

            119  Y*0(1800) WIDTH  (MEV) (PROD. EXP.)

W  C    60   24.       8.              LOCKMAN    78 SPEC  0 PP TO L PI PI X  12/79*
W  C    OBSERVED WIDTH CONSISTENT WITH EXPERIMENTAL RESOLUTION.

            119  Y*0(1800) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1      Y*0(1800) INTO LAMBDA PI PI                      1115+ 139+ 139
P2      Y*0(1800) INTO Y*1(1385) PI                      1384+ 139
P3      Y*0(1800) INTO Y*1(1560) PI                      1553+ 139

            119  Y*0(1800) BRANCHING RATIOS (PROD. EXP.)

R1      Y*0(1800) INTO LAMBDA PI PI                       (P1)
R1         SEEN                        LOCKMAN    78 SPEC  0 PP TO L PI PI X  12/79*

R2      Y*0(1800) INTO Y*1(1385) PI                       (P2)
R2         SEEN                        LOCKMAN    78 SPEC  0 PP TO L PI PI X  12/79*

R3      Y*0(1800) INTO Y*1(1560) PI                       (P3)
R3         SEEN                        LOCKMAN    78 SPEC  0 PP TO L PI PI X  12/79*
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            REFERENCES FOR Y*0(1800) (PROD. EXP.)

LOCKMAN  78  CEN DPHPE 78-01  +MEYER,RANDER,POSTER,SCHLEIN+    (UCLA+SACL)
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Λ(1815) **F'05**

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39  Y*0(1815, JP=5/2+) I=0

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THIS STATE IS WELL ESTABLISHED. MOST OF THE QUOTED ER-
RORS ARE STATISTICAL ONLY. THE SYSTEMATIC ERRORS DUE TO
THE PARTICULAR PARAMETRIZATION USED IN THE P.W.A. ARE
NOT INCLUDED. FOR THIS REASON WE DO NOT CALCULATE WEIGHTED AVERAGES FOR
MASS AND WIDTH.

            39  Y*0(1815) MASS (MEV)

M    N       1813.0     (2.0)          ARMENT-1   67 HBC   0 K-P TO SIGMA PI    8/67
M    N       1816.0     (4.0)          BELL       67 HDBC  0 K-N TO SIGMA PI   11/67
M    N       1817.0     (2.0)          ARMENT-3   68 HBC   0 ELASTIC, CH EXCH 11/68
M    N       1819.0     (4.0)          BUGG       68 CNTR  0 K-P, D TOTAL       6/68
M    N       1825.0     (1.0)          BRICMAN    70 CNTR  0 TOTAL AND CH EX    6/70
M    N       1819.0     (1.0)          BRICMAN1   70 DPWA    SIGTOT,ELAS,CHEX   1/71
M            1830.0    (10.0)          COOL       70 CNTR    K-P, D TOTAL      10/70
M            1820.0    (10.0)          GALTIERI   70 DPWA  0 K-P TO SIGMA PI    7/70
M    N       1818.0     (2.0)          CONFORTO   71 DPWA  0 ELASTIC, CH EXCH   6/70
M            1810.                     KIM        71 DPWA    K-MATRIX ANAL.     3/71
M    N       1823.0     (3.0)          KANE       72 DPWA  0 K-P TO PI SIG     10/71
M    N       1818.0     (3.0)          LANGBEIN   72 IPWA    MULTICHANNEL      12/72
M           (1830.)                    DECLAIS    77 DPWA    KBAR N TO KBAR N   1/78
M    2       1817. OR 1819.            MARTIN     77 DPWA    KBAR N MULTICHNL  11/77
M    2  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    2  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M    N       1822.      (2.)           RLIC       77 DPWA    KBAR N MULTICHNL   1/76
M            1819.      (2.)           ALSTON     78 DPWA    KBAR N ELASTIC     1/78
M    N   ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED     1/71

            39  Y*0(1815) WIDTH (MEV)

W              87.0    (15.0)          ARMENT-1   67 HBC   0                    8/67
W              64.0    (12.0)          BELL       67 HDBC  0                   11/67
W    N         71.0     (4.0)          ARMENT-3   68 HBC   0 ELASTIC, CH EXCH 11/68
W    N         75.0     (7.0)          BUGG       68 CNTR  0 K-P, D TOTAL       6/68
W    N         80.0     (6.0)          BRICMAN    70 CNTR  0 TOTAL AND CH EX    6/70
W    N         79.0     (3.0)          BRICMAN1   70 DPWA    SIGTOT,ELAS,CHEX   1/71
W             100.0                    COOL       70 CNTR    K-P, D TOTAL      10/70
W             100.0    (20.0)          GALTIERI   70 DPWA  0 K-P TO SIGMA PI    7/70
W    N         90.0     (4.0)          CONFORTO   71 DPWA  0 ELASTIC, CH EXCH   6/70
W              70.                     KIM        71 DPWA    K-MATRIX ANAL.     3/71
W    N        104.0    (16.0)          KANE       72 DPWA  0 K-P TO PI SIG     10/71
W    N         70.0     (5.0)          LANGBEIN   72 IPWA    MULTICHANNEL      12/72
W             (82.)                    DECLAIS    77 DPWA    KBAR N TO KBAR N   1/78
W    2         76. OR 76.              MARTIN     77 DPWA    KBAR N MULTICHNL  11/77
W    N         81.      (5.)           RLIC       77 DPWA    KBAR N MULTICHNL   1/76
W              72.      (2.)           ALSTON     78 DPWA    KBAR N ELASTIC     1/78
         SEE THE NOTES ACCOMPANYING MASSES QUOTED

            39  Y*0(1815) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Y*0(1815) INTO KBAR N                            497+ 939
P2      Y*0(1815) INTO SIGMA PI                          1189+ 139
P3      Y*0(1815) INTO SIGMA PI PI                       1192+ 139+ 139
P4      Y*0(1815) INTO ETA LAMBDA                         548+1115
P5      Y*0(1815) INTO Y*1(1385) PI P-WAVE                139+1384
P6      Y*0(1815) INTO Y*1(1385) PI F-WAVE                139+1384
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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

```
          P 1          P 2          P 3          P 4          P 5          P 6
P 1  .6008+-.0193
P 2   -.4763  .1155+-.0078
P 3   -.1042      .0496  .1034+-.0287
P 4   -.3565     -.0111     -.8126  .1579+-.0334
P 5   -.0579      .0276      .0060     -.2343  .0153+-.0085
P 6   -.0361      .0172      .0038     -.1750      .0021  .0070+-.0063
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            39  Y*0(1815) BRANCHING RATIOS

     ERRORS QUOTED BY EXPERIMENTERS DO NOT INCLUDE UNCERTAINTY DUE
     TO PARAMETRIZATION USED IN THE P.W.A.  THEY SHOULD BE INCREASED.

R1      Y*0(1815) INTO (KBAR N)/TOTAL                      (P1)
R1           0.62      0.02            ARMENT-3   68 HBC   0 ELASTIC, CH EXCH 11/68
R1          (0.72)                     BUGG       68 CNTR  0 K-P, D TOTAL       6/68
R1           0.65      0.02            BRICMAN    70 CNTR  0 TOTAL AND CH EX    6/70
R1           0.58      0.02            BRICMAN1   70 DPWA    SIGTOT,ELAS,CHEX   1/71
R1          (0.8)                      COOL       70 CNTR    K-P, D TOTAL      10/70
R1           0.63      0.01            CONFORTO   71 DPWA  0 ELASTIC, CH EXCH   6/70
R1          (0.52)                     KIM        71 DPWA    K-MATRIX ANAL.     3/71
R1           0.47      0.02            LANGBEIN   72 IPWA    MULTICHANNEL      12/72
R1          (.51)                      DECLAIS    77 DPWA    KBAR N TO KBAR N   1/78
R1   2      (.59)OR .58                MARTIN     77 DPWA    KBAR N MULTICHNL  11/77
R1           .57       .02             RLIC       77 DPWA    KBAR N MULTICHNL   1/76
R1           .60       .03             ALSTON     78 DPWA    KBAR N ELASTIC     1/78
R1
R1   AVG     0.601     0.021   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.2)
R1   STUDENT 0.6128    0.0100  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1   FIT     0.601     0.019   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 3.0)

R2      Y*0(1815) FROM KBAR N INTO SIGMA PI                SQRT(P1*P2)
R2   1      -0.27      0.01            ARMENT-1   67 DPWA  0 K-P TO SIGMA PI   10/74
R2   1 PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT) 10/74
R2           0.23      0.025           BELL       67 DPWA  0 K-N TO SIGMA PI   11/67
R2          -0.26      0.03            GALTIERI   70 DPWA  0 K-P TO SIGMA PI    7/70
R2          (0.26)                     KIM        71 DPWA    K-MATRIX ANAL.     3/71
R2          -0.268     0.027           KANE       72 DPWA  0 K P TO PI SIG     10/71
R2           0.25      0.03            LANGBEIN   72 IPWA    MULTICHANNEL      12/72
R2   2     (-.25)OR -.25               MARTIN     77 DPWA    KBAR N MULTICHNL  11/77
R2          -.28       .03             RLIC       77 DPWA    KBAR N MULTICHNL   1/76
R2
R2   AVG MOD 0.2645    0.0078  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2   STUDENT 0.2650    0.0087  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2   FIT     0.2635    0.0078  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      Y*0(1815) FROM KBAR N TO ETA LAMBDA                SQRT(P1*P4)         9/73
R3          -.096      .040      .020 RADER      73 MPWA                        9/73
R3
R3   FIT     0.096     0.027   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4      Y*0(1815) INTO (Y*1(1385) PI)/TOTAL                (P5)
R4           0.20      0.05            BIRGE      65 HBC   0 K-P TO LAM PI PI   7/66
R4
R4   FIT     0.103     0.029   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R5      Y*0(1815) INTO (SIGMA PI PI)/TOTAL                 (P3)
R5   P     NO CLEAR SIGNAL             ARMENT-4   68 HDBC  0 K-N TO SIG PI PI 11/68
R5   P     THERE IS A SUGGESTION OF A BUMP, ENOUGH TO BE CONSISTENT WITH
R5      WHAT IS EXPECTED FROM SIGMA PI DECAY OF THE Y*1(1385) -- ABOUT 0.02.
R5
R5   FIT     0.158     0.033   FROM FIT

R6      Y*0(1815) FROM KBAR N TO Y*1(1385) PI P-WAVE       SQRT(P1*P5)
R6   A      (0.3)     (0.05)           ARMENT-2   67 HBC   0 K-P TO LAM P+ P+
R6          +.27       .03             PREVOST    74 DPWA 0- K-N TO S(1385)PI 10/74
R6   3      -.167      .054            CAMERON    78 DPWA  0 K-P TO S(1385)PI  1/78
R6
R6   AVG MOD 0.246     0.044   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R6   STUDENT 0.248     0.031   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R6   FIT     0.249     0.034   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R7      Y*0(1815) FROM KBAR N TO Y*1(1385) PI F-WAVE       SQRT(P1*P6)
R7   3      +.065      .029            CAMERON    78 DPWA  0 K-P TO S(1385)PI  1/78
R7   3   THE SIGN HERE AND IN R6 IS CHANGED TO BE IN ACCORD WITH THE          12/79*
R7   3   BARYON-FIRST CONVENTION.                                              12/79*
R7
R7   FIT     0.065     0.029   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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REFERENCES FOR Y*0(1815)


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BIRGE     65 ATHENS CONF   296  +ELY,KALMUS,KERNAN,LOUIE,SAHOURIA, +  (LRL)IJP
ARMENT-1  67 PL 24B 198         ARMENTEROS, F LUZZI, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-2  67 ZEIT PHYS 202 486  ARMENTEROS, F LUZZI, + (CERN,HEIDEL,SACLAY)IJP
BELL      67 PRL 19 936         R B BELL                              (LRL)IJP
ARMENT-3  68 NP B8 195          ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-4  68 NP B8 216          ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY) I
BUGG      68 PR 168 1466        +GILMORE, KNIGHT,    +     (RHEL+BIRM+CAVE) I

BRICMAN   70 PL 31B 152         +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
BRICMAN1  70 PL 33B 511         +FERRO-LUZZI,LAGNAUX                  (CERN)
COOL      70 PR D1 1887         +GIACOMELLI, KYCIA, LEONTIC, LI, +     (BNL) I
GALTIERI  70 DUKE CONF 173      A BARBARO-GALTIERI                    (LRL)IJP

CONFORTO  71 NP  B34  41        +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM       71 PRL 27 356         J K KIM                              (HARV)IJP
   ALSO   70 DUKE 161           J. K. KIM                            (HARV)IJP

KANE      72 PR D5 1583         D F KANE                              (LBL)IJP
LANGBEIN  72 NP B47 477         +WAGNER                              (MPIM)IJP
RADER     73 NC 16A 178         +BARLOUTAUD,+     (SACL+HEID+CERN+RHEL+CDEF)
PREVOST   74 NP B69 246         PREVOST,BARLOUTAUD,+          (SACL+CERN+HEID)
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Data Card Listings

For notation, see key at front of Listings.

Baryons

Λ(1815), Λ(1830), Λ(1860)


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DECLAIS  77  CERN 77-16          +DUCHON,LOUVEL,PATRY,SEGUINOT+   (CAEN+CERN)IJP
MARTIN   77 NP B127 349          MARTIN,PIDCOCK,MOORHOUSE         (LOUC+GLAS)IJP
   ALSO  77 NP B126 266          MARTIN,PIDCOCK                        (LOUC)
   ALSO  77 NP B126 285          MARTIN,PIDCOCK                        (LOUC)IJP
RLIC     77 NP B119 362          GOPAL,ROSS,VAN HORN,MCPHERSON+   (LOIC+RHEL)IJP
ALSTON   78 PR D18 182           +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
   ALSO  77 PRL 38 1007          ALSTON-GARNJOST,KENNEY       (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189          +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP

                                 PAPERS NOT REFERRED TO IN DATA CARDS

          THE FOLLOWING PAPERS ARE NOW OF ONLY HISTORICAL INTEREST --

CHAMBERL 62 PR 125 1696          CHAMBERLAIN,CROWE,KEEFE,KERTH, +       (LRL) I
GALTIERI 63 PL 6 296             A BARBARO-GALTIERI,A HUSSAIN,RD TRIPP (LRL)IJ
SODICKSO 64 PR 133 B757          SODICKSON,MANNELLI,FRISCH,WAHLIG (MIT(BNL)) J
HOLLEY   65 UCRL-16274 THESIS    W R HOLLEY                             (LRL) J
BIRMINGH 66 PR  152  1148        BIRMINGHAM,GLASGOW,I.C., OXFORD,RUTHERFORD
COOL     66 PRL 16 1228          +GIACOMELLI,KYCIA,LEONTIC,LUNDBY +     (BNL)I
GELFAND  66 PRL 17 1224          +HARMSEN,LEVI-SETTI,PREDAZZI+      (EFI,ANL)
ARMENTER 67 NP B3 592            ARMENTEROS,FERRO-LUZZI+  (CERN,HEID,SACLAY)IJP
CONFORTO 68 NP B8 265            +HARMSEN, LASINSKI, +      (CHICAGO,HEIDEL)IJP
LASINSKI 68 PR 163 1792          LASINSKI, LEVI SETTI, PREDAZZI    (CHICAGO) JP
PREVOST  71  AMSTERDAM CONF      + CHS COLLABORATION           (CERN+HEID+SACL)
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Λ(1830) — D_{05}

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56  Y*0(1830, JP=5/2-) I=0

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THE BEST EVIDENCE FOR THIS RESONANCE COMES FROM THE
SIGMA PI CHANNEL.  IT IS WELL ESTABLISHED.

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                    56  Y*0(1830) MASS (MEV)

M    N     1827.0     (3.0)          ARMENTERO 67 HBC   0 K-P TO SIGMA PI    8/67
M    N     1837.0    (11.0)          BELL      67 HBC   0 K-P TO SIGMA PI   11/67
M    N     1807.0    (10.0)          ARMENTERO 68 HBC   0 ELASTIC, CH EXCH 11/68
M          1840.0    (15.0)          GALTIERI  70 DPWA  0 K-P TO SIGMA PI    7/70
M    N     1831.0     (5.0)          CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
M          1830.                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
M    K    (1720.)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
M          1832.0      (5.0)         KANE      72 DPWA  0 K-P TO PI SIG    10/71
M          1810.0    (10.0)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72
M    1     1817. OR 1818.            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    1  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESCNANCE
M    1  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1825.      (10.)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M    K POSSIBLE EFFECT MAINLY IN SIGMA PI.  NOT CLEAR IF UNCORRELATED
M    K WITH THE 1830 EFFECT
M    N   ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED  1/71

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                    56  Y*0(1830) WIDTH (MEV)

W            75.0     (9.0)          ARMENTERO 67 HBC   0 K-P TO SIGMA PI    8/67
W            74.0    (18.0)          BELL      67 HBC   0 K-P TO SIGMA PI    8/67
W           123.0    (32.0)          ARMENTERO 68 HBC   0 ELASTIC, CH EXCH 11/68
W           150.0    (30.0)          GALTIERI  70 DPWA  0 K-P TO SIGMA PI    7/70
W           104.0    (35.0)          CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
W            80.                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
W    K      (20.)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
W            88.0    (10.0)          KANE      72 DPWA  0 K-P TO PI SIG    10/71
W            60.0    (20.0)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W    1       56. OR 56.              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W            94.     (10.)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
        SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                    56  Y*0(1830) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1     Y*0(1830) INTO KBAR N                         497+ 939
P2     Y*0(1830) INTO SIGMA PI                      1189+ 139
P3     Y*0(1830) INTO Y*1(1385) PI D-WAVE            139+1384
P4     Y*0(1830) INTO ETA LAMBDA                     548+1115

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                    56  Y*0(1830) BRANCHING RATIOS

R1     Y*0(1830) INTO (KBAR N)/TOTAL                        (P1)
R1            0.09    (0.01)         ARMENTERO 68 HBC   0 ELASTIC, CH EXCH 11/68
R1            0.03    (0.02)         BRICMAN1  70 DPWA    SIGTOT,ELAS,CHEX  1/71
R1            0.05    (0.02)         CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
R1           (0.24)                  KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1            0.10    (0.03)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1   1       (.04)OR .04             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1             .04     (.03)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1             .02     (.02)         ALSTON    78 DPWA    KBAR N ELASTIC    1/78

R2     Y*0(1830) FROM KBAR N INTO SIGMA PI                  SQRT(P1*P2)
R2   A      (-0.15)   (0.02)         ARMENTERO 67 DPWA  0 K-P TO SIGMA PI  10/74
R2   A  PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT) 10/74
R2            0.19    (0.01)         BELL      67 DPWA  0 K-P TO SIGMA PI  11/67
R2           -0.16    (0.03)         GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
R2            0.15                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2           -0.138   (0.018)        KANE      72 DPWA  0 K-P TO PI SIG    10/71
R2            0.27    (0.07)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R2   1      (-.17)OR -.17            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2            -.17     (.03)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3     Y*0(1830) FROM KBAR N TO ETA LAMBDA                  SQRT(P1*P4)        9/73
R3           -.044     .020          RADER     73 MPWA                         9/73

R4     Y*0(1830) FROM KBAR N TO Y*1(1385) PI D-WAVE         SQRT(P1*P3)
R4            +.13      .03          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
R4   2        +.141     .014         CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R4   2  CAMERON  78 UPPER LIMIT ON G-WAVE DECAY IS 0.03.  THE SIGN HERE IS  12/79*
R4   2  CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.           12/79*
R4          . . . . . . . . . .
R4  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                                 REFERENCES FOR Y*0(1830)

ARMENTER 67 PL 24B 198           ARMENTEROS, F-LUZZI, + (CERN,HEIDEL,SACLAY)IJP
BELL     67 PRL 19 936           R B BELL                               (LRL)IJP
ARMENTER 68 NP B8 195            ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
CONFORTO 68 NP B8 265            +HARMSEN, LASINSKI, +       (CHICAGO,HEIDEL)IJP
   IS SUPERSEDED BY CCNFORTO 71.
BRICMAN1 70 PL 33B 511           +FERRO-LUZZI,LAGNAUX                  (CERN)
GALTIERI 70 DUKE CONF 173        A BARBARO-GALTIERI                     (LRL)IJP

CONFORTO 71 NP  B34  41          +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM      71 PRL 27 356           J K KIM                               (HARV)IJP
   ALSO  70 DUKE 161             J. K. KIM                             (HARV)IJP
KANE     72 PR D5 1583           D F KANE                               (LBL)IJP
LANGBEIN 72 NP B47 477           +WAGNER                               (MPIM)IJP
RADER    73 NC 16A 178           +BARLOUTAUD,+     (SACL+HEID+CERN+RHEL+CDEF)

PREVOST  74 NP B69 246           PREVOST,BARLOUTAUD,+         (SACL+CERN+HEID)

MARTIN   77 NP B127 349          MARTIN,PIDCOCK,MOORHOUSE          (LOUC+GLAS)IJP
   ALSO  77 NP B126 266          MARTIN,PIDCOCK                         (LOUC)
   ALSO  77 NP B126 285          MARTIN,PIDCOCK                         (LCUC)IJP
RLIC     77 NP B119 362          GOPAL,ROSS,VAN HORN,MCPHERSON+   (LOIC+RHEL)IJP
ALSTON   78 PR D18 182           +KENNEY,POLLARD,ROSS+         (LBL+MTHO+CERN)IJP
   ALSO  77 PRL 38 1007          ALSTON-GARNJOST,KENNEY        (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189          +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP

                                 PAPERS NOT REFERRED TO IN DATA CARDS

PREVOST  71  AMSTERDAM CONF      + CHS COLLABORATION          (CERN+HEID+SACL)
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Λ(1860) — P_{03}

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60  Y*0(1860, JP=3/2+) I=0

THE JP=3/2+ ASSIGNMENT IS CONSISTENT WITH ALL
AVAILABLE DATA (INCLUDING POLARIZATION) AND RECENT
PARTIAL WAVE ANALYSES. THE DOMINANT INELASTIC
MODES REMAIN UNKNOWN.  SEE ALSO Y*0(2010) MINI-REVIEW.

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                    60  Y*0(1860) MASS (MEV)

M   A  F07 1864.0      2.0           ARMENTERO 68 DPWA  0 ELASTIC, CH EXCH 11/68
M    N     1870.0      5.0           BUGG      68 CNTR  0 K-P TOTAL         7/68
M   A  F07 1877.0      6.0           BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
M          1870.0      6.0           BRICMAN1  70 DPWA  0 SIGTOT,ELAS,CHEX  1/71
M    N     1883.0     10.0           CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
M   1     (1710.)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
M          1850.0     20.0           LANGBEIN  72 IPWA    MULTICHANNEL     12/72
M    2    (1868.)                    LEA       73 DPWA    MULTICHNL K-MTRX  9/73
M          1894.      10.            HEMINGWA  75 DPWA  0 K- P TO KBAR N   11/75
M    3    (1900.)                    NAKKASYA  75 DPWA  0 K-P TO LAM. OMG.  1/76
M          SEEN                      BACCARI   77 IPWA  0 K-P TO LAM. OMG.  1/78
M    4     1856. OR 1868.            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    4  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    4  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1900.       5.            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          1908.      10.            ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M   A    THESE TWO ANALYSES GAVE THE F07 ASSIGNMENT, THEY HAVE TO BE         1/71
M   A    DISCARDED IN VIEW OF CONFORTO 70 AND BRICMAN1 70
M    N   DUE TO PARTICULAR PARAMETERIZATION USED,ERROR CAN BE LARGE          1/71
M   1  POSSIBLE EFFECT MAINLY IN SIGMA PI. WE TENTATIVELY LIST IT HERE.
M    2  CNLY UNCONSTRAINED STATES FROM TABLE 1 OF LEA73 ARE IN LISTINGS.     9/73
M    3  FOUND IN ONE OF TWO BEST SOLUTIONS.                                  1/76
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.4)

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                    60  Y*0(1860) WIDTH (MEV)

W   A  F07   39.0      7.0           ARMENTERO 68 DPWA  0 ELASTIC, CH EXCH 11/68
W    N       40.0     10.0           BUGG      68 CNTR  0 K-P TOTAL         7/68
W   A  F07   24.0     15.0           BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
W            37.0     10.0           BRICMAN1  70 DPWA  0 SIGTOT,ELAS,CHEX  1/71
W    N       80.0     20.0           CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
W   1       (20.)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
W           125.0     20.0           LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W    2     (323.8)                   LEA       73 DPWA    MULTICHNL K-MTRX  9/73
W           107.      10.            HEMINGWA  75 DPWA  0 K- P TO KBAR N   11/75
W    3     (100.)                    NAKKASYA  75 DPWA  0 K-P TO LAM. OMG.  1/76
W    4      191. OR 193.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W            72.      10.            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W           119.      20.            ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W       SEE THE NOTES ACCOMPANYING MASSES QUOTED
W          . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 2.8)

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                    60  Y*0(1860) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1     Y*0(1860) INTO KBAR N                         497+ 939
P2     Y*0(1860) INTO SIGMA PI                      1189+ 139
P3     Y*0(1860) INTO LAMBDA OMEGA                  1115+ 782
P4     Y*0(1860) INTO Y*1(1385) PI P-WAVE            139+1384
P5     Y*0(1860) INTO Y*1(1385) PI F-WAVE            139+1384
P6     Y*0(1860) INTO N K*(890), P1 WAVE             939+ 892

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                    60  Y*0(1860) BRANCHING RATIOS

R1     Y*0(1860) INTO (KBAR N)/TOTAL                        (P1)
R1  A  F07    0.12      0.02         ARMENTERO 68 HBC   0 ELASTIC, CH EXCH 11/68
R1         (J+1/2)P1= 0.40           BUGG      68 CNTR  0                   7/68
R1  A  F07    0.07      0.02         BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
R1            0.14      0.02         BRICMAN1  70 DPWA  0 SIGTOT,ELAS,CHEX  1/71
R1   N        0.25      0.03         CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
R1            0.37      0.05         LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1   2       (.32)                   LEA       73 DPWA    MULTICHNL K-MTRX  9/73
R1             .24       .04         HEMINGWA  75 DPWA  0 K- P TO KBAR N   11/75
R1   4       (.36)OR .34             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1             .18       .02         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1             .34       .05         ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1      SEE THE NOTES ACCOMPANYING MASSES QUOTED
R1          . . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 2.6)
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Baryons

Λ(1860), Λ(2010), Λ(2020), Λ(2100)

Data Card Listings

For notation, see key at front of Listings.

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R2      Y*0(1860) INTO SIGMA PI                          (P2)
R2   P     PROBABLY SEEN                 GALTIERI  68 DBC   0 K-N TO SIG PI PI 11/68
R2           (0.03) OR LESS              LANGBEIN  72 IPWA     MULTICHANNEL    12/72
R2   P   POSSIBLY THIS BUMP SEEN AT 1840+-10 MEV WITH A WIDTH OF 35+-10 MEV
R2       IS THE Y*0(1830), WHICH DECAYS STRONGLY TO SIGMA PI.  HOWEVER THE
R2       NARROW WIDTH HERE ARGUES FOR ITS BEING THE Y*0(1860).

R3      Y*0(1860) FROM KBAR N TO SIGMA PI                SQRT(P1*P2)         9/73
R3   2        (+.15)                     LEA       73 DPWA    MULTICHNNL K-MTRX  9/73
R3   4        (+.15)OR +.14              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R3            -.09         .03           RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R4      Y*0(1860) FROM KBAR N INTO LAMBDA OMEGA          SQRT(P1*P3)         1/76
R4   3        (.032)                     NAKKASYA  75 DPWA  0 K-P TO LAM. OMG.  1/76

R5      Y*0(1860) FROM KBAR N INTO Y*1(1385) PI P-WAVE   SQRT(P1*P4)
R5        LESS THAN 0.03                 CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78

R6      Y*0(1860) FROM KBAR N INTO Y*1(1385) PI F-WAVE   SQRT(P1*P5)
R6   5        -.126        .055          CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R6   5   SIGN CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.      12/79*

R7      Y*0(1860) FROM KBAR N INTO N K*(890), P1 WAVE    SQRT(P1*P6)
R7   6       -0.07       0.03            CAMERON2  78 DPWA    K-P TO K*N       12/79*
R7   6   THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST       12/79*
R7   6   CONVENTION.  UPPER LIMITS ON THE P3 AND F3 WAVES ARE EACH 0.03.      12/79*

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REFERENCES FOR Y*0(1860)


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ARMENTERO68 NP B8 195            ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BUGG      68 PR 168 1466         +GILMORE, KNIGHT, +        (RHEL,BIRM,CAVE) I
GALTIERI 68 PRL 21 573           BARBARO-GALTIERI, MATISON, +     (LRL,SLAC)

BRICMAN   70 PL 31B 152          +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
BRICMAN1 70 PL 33B 511           +FERRO-LUZZI,LAGNAUX                (CERN)
CONFORTO 71 NP  B34  41          +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM       71 PRL 27 356          J K KIM                            (HARV)IJP
   ALSO 70 DUKE 161              J. K. KIM                          (HARV)IJP
LANGBEIN 72 NP B47 477           +WAGNER                            (MPIM)IJP

LEA       73 NP B56 77           +MARTIN,MOORHOUSE+  (RHEL+LOUC+GLAS+AARHUS)IJP
HEMINGWA 75 NP B91 12            HEMINGWAY,EADES,HARMSEN+   (CERN,HEID,MPIM)IJP
NAKKASYA 75 NP B93 85            A. NAKKASYAN                       (CERN)IJP

MARTIN    77 NP B127 349         MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
   ALSO 77 NP B126 266           MARTIN,PIDCOCK                     (LOUC)
   ALSO 77 NP B126 285           MARTIN,PIDCOCK                     (LOUC)IJP
RLIC      77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON    78 PR D18 182          +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
   ALSO 77 PRL 38 1007           ALSTON-GARNJOST,KENNEY      (LBL+MTHO+CERN)IJP
CAMERON   78 NP B143 189         +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327          +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
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PAPERS NOT REFERRED TO IN DATA CARDS


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ARMENTER 67 NP B3 592            ARMENTEROS, F-LUZZI, + (CERN,HEIDEL,SACLAY)IJP
   REPLACED BY ARMENTEROS 68 AND CONFORTO 68.
CONFORTC 68 NP B8 265            +HARMSEN, LASINSKI, +       (CHICAGO,HEIDEL)IJP
   SUPERSEDED BY CONFORTO 71.
LEVISETT 69 LUND 339             R.LEVI SETTI  (RAPPORTEUR)           (EFI)
ALBROW    71 NP  B29 413         +ANDERSON,BOSNJAKOVIC,DAUM,ERNZ,+    (CERN)
BACCARI   77 NC 41A 96           +POULARD,REVEL,TALLINI+         (SACL+CDEF)IJP
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Λ(2010)

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 89  Y*0(2010,        ) I=0

 SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

 WE LIST HERE ALL THE AMBIGUOUS RESONANCE POSSIBLITIES
 WITH A MASS AROUND 2 GEV.  THE PROPOSED QUANTUM NUMBERS
 ARE D3 (GALTIERI 70 IN SIGMA PI), D3+F5, P3+D5, OR
 P1+D3 (BRANDSTETTER 72 IN LAMBDA OMEGA), AND S1
(CAMERON2 78 IN NK*).  THE FIRST TWO OF THE ABOVE ANALYSES SHOULD NOW
BE CONSIDERED OBSOLETE.

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                  89  Y*0(2010) MASS (MEV)

M           (2010.0)    (30.0)           GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
M    1        1935. TO 1971.             BRANDSTE  72 DPWA  0 K-P TO LAM. OMG.  1/74
M    1        1951. TO 2034.             BRANDSTE  72 DPWA  0 K-P TO LAM. OMG.  1/74
M    1   PARAMETERS QUOTED ARE RANGES FROM THREE BEST FITS, THE LOWER         11/75
M    1   (HIGHER) MASS STATE PROBABLY HAS J.LE.3/2(5/2).                      11/75
M             2030.0       30.0          CAMERON2  78 DPWA    K-P TO K*(890) N 12/79*

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                  89  Y*0(2010) WIDTH (MEV)

W           (130.0)     (50.0)           GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
W    1        180. TO  240. (LWR. MASS) BRANDSTE  72 DPWA  0 K-P TO LAM. OMG.  1/74
W    1         73. TO  154. (HGR. MASS) BRANDSTE  72 DPWA  0 K-P TO LAM. OMG.  1/74
W             125.0        25.0          CAMERON2  78 DPWA    K-P TO K*(890) N 12/79*
        SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                  89  Y*0(2010) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Y*0(2010) INTO KBAR N                            497+ 939
P2      Y*0(2010) INTO SIGMA PI                          1197+ 139
P3      Y*0(2010) INTO LAMBDA OMEGA                      1115+ 782
P4      Y*0(2010) INTO N K*(890), S1 WAVE                 939+ 892
P5      Y*0(2010) INTO N K*(890), D3 WAVE                 939+ 892

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                  89  Y*0(2010) BRANCHING RATIOS

R1      Y*0(2010) FROM KBAR N TO SIGMA PI                SQRT(P1*P2)
R1         (-0.20)     (0.04)            GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70

R2      Y*0(2010) FROM KBAR N INTO LAMBDA OMEGA          SQRT(P1*P3)
R2   1        (.17) TO  .25 (LWR.)       BRANDSTE  72 DPWA  0 K-P TO LAM. OMG.  1/74
R2   1        (.04) TO  .15 (HGR.)       BRANDSTE  72 DPWA  0 K-P TO LAM. OMG.  1/74

R3      Y*0(2010) FROM KBAR N INTO N K*(890), S1 WAVE    SQRT(P1*P4)
R3   2       -0.12       0.03            CAMERON2  78 DPWA    K-P TO K*N       12/79*
R3   2   THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST       12/79*
R3   2   CONVENTION.                                                          12/79*

R4      Y*0(2010) FROM KBAR N INTO N K*(890), D3 WAVE    SQRT(P1*P5)
R4            +0.09       0.03           CAMERON2  78 DPWA    K-P TO K*N       12/79*

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REFERENCES FOR Y*0(2010)


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GALTIERI 70 DUKE CONF 173        A BARBARO-GALTIERI                  (LRL)IJP
BRANDSTE 72 NP B39 13            BRANDSTETTER,BUTTERWORTH,+ (RHEL+CDEF+SACL)
CAMERON2 78 NP B146 327          +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
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PAPERS NOT REFERRED TO IN DATA CARDS


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NAKKASYA 75 NP B93 85            A. NAKKASYAN                        (CERN)IJP
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Λ(2020) F07

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 27  Y*0(2020, JP=7/2+) I=0

 EFFECTS IN THIS PARTIAL WAVE HAVE OBSERVED AT SOMEWHAT
 DIFFERENT ENERGIES IN TWO CHANNELS. HOWEVER, LITCHFIELD
 71 NOTE THAT THE NEED FOR THIS STATE IN THEIR ANALYSIS
 RESTS SOLELY ON A POSSIBLY INCONSISTENT POLARIZATION
 MEASUREMENT AT 1.784 GEV/C.  THE STATE WAS NOT REQUIRED
 IN THE KBAR N TO KBAR N ANALYSIS OF HEMINGWAY 75, BUT
 COULD NOT BE CONCLUSIVELY RULED OUT.  IT IS NOW
 SEEN IN THE NEW ANALYSIS OF DECLAIS 77 WHICH INCLUDES
 K- NEUTRON ELASTIC DIFFERENTIAL CROSS SECTION DATA,
 AND IS WEAKLY SUPPORTED BY BACCARI 77.

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                  27  Y*0(2020) MASS (MEV)

M           (2020.0)    (20.0)           GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
M           (2100.)     (30.)            LITCHFIE  71 DPWA    K-P TO KBAR N    10/71
M           (2140.)                      BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78
M           (2117.)                      DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78

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                  27  Y*0(2020) WIDTH (MEV)

W           (160.0)     (30.0)           GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
W           (120.)      (30.)            LITCHFIE  71 DPWA    K-P TO KBAR N    10/71
W           (128.)                       BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78
W           (167.)                       DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78

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                  27  Y*0(2020) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Y*0(2020) INTO KBAR N                            497+ 939
P2      Y*0(2020) INTO SIGMA PI                          1197+ 139
P3      Y*0(2020) INTO LAMBDA OMEGA                      1115+ 782

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                  27  Y*0(2020) BRANCHING RATIOS

R1      Y*0(2020) INTO (KBAR N)/TOTAL                    (P1)
R1          (0.05)      (0.02)           LITCHFIE  71 DPWA    K-P TO KBAR N    10/71
R1          (.05)                        DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78

R2      Y*0(2020) FROM KBAR N TO SIGMA PI                SQRT(P1*P2)
R2         (-0.15)      (0.02)           GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70

R3      Y*0(2020) FROM KBAR N TO LAMBDA OMEGA            SQRT(P1*P3)         1/78
R3        LESS THAN .05                  BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78

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REFERENCES FOR Y*0(2020)


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GALTIERI 70 DUKE CONF 173        A BARBARO-GALTIERI                  (LRL)IJP
LITCHFIE 71 NP  B30 125          LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP

BACCARI   77 NC 41A 96           +POULARD,REVEL,TALLINI+         (SACL+CDEF)IJP
DECLAIS   77  CERN 77-16         +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP
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PAPERS NOT REFERRED TO IN DATA CARDS


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HEMINGWA 75 NP B91 12            HEMINGWAY,EADES,HARMSEN+    (CERN,HEID,MPIM)IJP
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Λ(2100) G07

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 41  Y*0(2100, JP=7/2-) I=0

 SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

 THIS ENTRY ONLY INCLUDES RESULTS FROM PARTIAL-WAVE
 ANALYSES.  PARAMETERS OF PEAKS SEEN IN CROSS-SECTIONS
 AND INVARIANT-MASS DISTRIBUTIONS AROUND 2100 MEV ARE
 GIVEN IN A SEPARATE ENTRY BELOW.

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                  41  Y*0(2100) MASS (MEV)

M           (2120.0)                     WOHL      66 HBC     K-P CH EX         7/66
M    A      (2080.0)    (10.0)           BURGUN    68 DPWA  0 K-P TO XI K      10/69
M    L      (2130.0)    (20.0)           BERTHON1  70 DPWA  0 K-P TO SIGMA PI  10/70
M             2110.0    (20.0)           GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
M             2100.     (15.)            LITCHFIE  71 DPWA    K-P TO KBAR N    10/71
M    L        2110.0    (30.0)           LITCHFIE  71 DPWA    K-P TO SIG PI    10/71
M    1        2113. TO 2154.             BRANDSTE  72 DPWA  0 K-P TO LAM. OMG.  1/74
M             2092.0    (12.0)           KANE      72 DPWA  0 K-P TO PI SIG    10/71
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M          2105.     (10.)              HEMINGWA  75 DPWA  O K- P TO KBAR N    11/75
M    2     2110. OR 2089.               NAKKASYA  75 DPWA  O K-P TO LAM. OMG. 11/75
M    3    (2094.)                       BACCARI   77 DPWA  O K-P TO LAM. OMG.  1/78
M         (2094.)                       DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78
M          2110.     (10.)              RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          2106.     (30.)              BELLEFON  78 DPWA  O KBAR N TO KBAR N  1/78
M    2  QUOTED PARAMETERS CORRESPOND TO THE TWO BEST SOLUTIONS FOUND.          11/75
M    2  EACH HAS THE Y*0(2100) AND ONE ADDITIONAL RESONANCE (P3 OR F5).        11/75
M    A     BURGUN 68 SEE A RESONANCE-LIKE EFFECT IN THIS REGION IN THE
M       REACTION K-P TO XI K.  HOWEVER, AS THEY POINT OUT, IT IS NOT CLEAR
M       WHETHER IT IS MAINLY THE G07 Y*0(2100) OR INSTEAD A SO FAR OTHERWISE
M       UNOBSERVED RESONANCE WITH A SPIN LESS THAN 7/2.
M    L  LITCHFIELD 71 IS AN UPDATE OF BERTHON1 70                               3/72
M    1  PARAMETERS QUOTED ARE RANGES FROM THREE BEST FITS.                      1/74
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41 Y*0(2100) WIDTH (MEV)

```
W         (145.0)                       WOHL      66 HBC                        7/66
W    A     (80.0)    (10.0)             BURGUN    68 DPWA  O K-P TO XI K       10/69
W          140.0     (15.0)             BERTHON1  70 DPWA  O K-P TO SIGMA PI  10/70
W           60.0     (25.0)             GALTIERI  70 DPWA  O K-P TO SIGMA PI   7/70
W    B    (170.) TO 300.                LITCHFIE  71 DPWA    K-P TO KBAR N    10/71
W    B  LARGER VALUE CORRESPONDS TO PURE B.W. LOWER VALUE , TO B.W. + BCKGRD
W    L     140.0     (50.0)    (30.0)   LITCHFIE  71 DPWA    K-P TO SIG PI    10/71
W    1     208. TO  229.                BRANDSTE  72 DPWA  O K-P TO LAM. OMG.  1/74
W          144.0     (26.0)             KANE      72 DPWA  O K-P TO PI SIG    10/71
W          241.      (30.)              HEMINGWA  75 DPWA  O K- P TO KBAR N   11/75
W    2     244. OR  302.                NAKKASYA  75 DPWA  O K-P TO LAM. OMG. 11/75
W    3     (98.)                        BACCARI   77 DPWA  O K-P TO LAM. OMG.  1/78
W         (250.)                        DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78
W          250.      (30.)              RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W          157.      (40.)              BELLEFON  78 DPWA  O KBAR N TO KBAR N  1/78
        SEE THE NOTES ACCOMPANYING MASSES QUOTED
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41 Y*0(2100) PARTIAL DECAY MODES

```
                                                           DECAY MASSES
P1      Y*0(2100) INTO KBAR N                               497+ 939
P2      Y*0(2100) INTO SIGMA PI                            1197+ 139
P3      Y*0(2100) INTO XI K                                1321+ 497
P4      Y*0(2100) INTO LAMBDA OMEGA                        1115+ 782
P5      Y*0(2100) INTO ETA LAMBDA                           548+1115
P6      Y*0(2100) INTO N K*(890), D3 WAVE                   939+ 892
P7      Y*0(2100) INTO N K*(890), G1 WAVE                   939+ 892
```

41 Y*0(2100) BRANCHING RATIOS

```
R1      Y*0(2100) INTO (KBAR N)/TOTAL                         (P1)
R1          (0.25)                      WOHL      66 HBC                        7/66
R1   D      (0.33)                      DAUM      68 CNTR    K-P ELA,POL,SIGT  7/70
R1           0.30      (.03)            LITCHFIE  71 DPWA    K-P TO KBAR N    10/71
R1            .31      (.03)            HEMINGWA  75 DPWA  O K- P TO KBAR N   11/75
R1           (.29)                      DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78
R1            .30      (.03)            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1            .24      (.06)            BELLEFON  78 DPWA  O KBAR N TO KBAR N  1/78
R1   D  DAUM 68 ASSUMES (J+1/2)*X VALUE SEEN IN TOTAL CROSS SECTION.

R2      Y*0(2100) FROM KBAR N INTO SIGMA PI                   SQRT(P1*P2)
R2   L     (+0.16)     (0.02)           BERTHON1  70 DPWA  O K-P TO SIGMA PI  10/70
R2          +0.06      (0.03)           GALTIERI  70 DPWA  O K-P TO SIGMA PI   7/70
R2   L       0.16      (0.05)           LITCHFIE  71 DPWA    K-P TO SIG PI    10/71
R2          +0.096     (0.037)          KANE      72 DPWA  O K-P TO PI SIG    10/71
R2           +.12      (.04)            RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3      Y*0(2100) FROM KBAR N TO XI K                         SQRT(P1*P3)
R3          (0.05)                      TRIPP     67 RVUE  O K-P TO XI K       8/67
R3   B      (0.09)     (0.01)           BURGUN    68 DPWA  O K-P TO XI K      10/69
R3          (0.003)                     MULLER    69 DPWA  O                   7/70
R3           0.035     0.018            LITCHFIE  71 DPWA    K-P TO XI K       3/72
R3   B  BURGUN 68 UPDATED BY LITCHFIELD 71, WHO TAKES SOLUTION C OF BURGUN      3/72

R4      Y*0(2100) FROM KBAR N INTO LAMBDA OMEGA               SQRT(P1*P4)
R4   1       (.05) TO  .11              BRANDSTE  72 DPWA  O K-P TO LAM. OMG.  1/74
R4   2      (.122)OR  .154              NAKKASYA  75 DPWA  O K-P TO LAM. OMG. 11/75
R4   3      (-.070)                     BACCARI   77 DPWA  O GD37-WAVE         1/78
R4   3      (+.011)                     BACCARI   77 DPWA  O GG17-WAVE         1/78
R4   3      (+.008)                     BACCARI   77 DPWA  O GG37-WAVE         1/78
R4   3  NOTE THAT THE 3 ENTRIES FOR BACCARI77 ARE FOR 3 DIFFERENT WAVES.        1/78

R5      Y*0(2100) FROM KBAR N TO ETA LAMBDA                   SQRT(P1*P5)       9/73
R5          -.050      .020             RADER     73 MPWA                       9/73

R6      Y*0(2100) FROM KBAR N INTO N K*(890), D3 WAVE    SQRT(P1*P6)
R6          +0.21      0.04             CAMERON2  78 DPWA    K-P TO K*N       12/79*

R7      Y*0(2100) FROM KBAR N INTO N K*(890), G1 WAVE    SQRT(P1*P7)
R7   4      -0.04      0.03             CAMERON2  78 DPWA    K-P TO K*N       12/79*
R7   4  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST         12/79*
R7   4  CONVENTION.  THE UPPER LIMIT ON THE G3 WAVE IS 0.03.                   12/79*

        SEE THE NOTES ACCOMPANYING MASSES QUOTED
```

REFERENCES FOR Y*0(2100)


```
WOHL     66 PRL 17 107           C G WOHL, F T SOLMITZ, M L STEVENSON  (LRL)IJP
TRIPP    67 NP B3 10             + LEITH, +      (LRL,SLAC,CERN,HEIDEL,SACLAY)
BURGUN   68 NP B8 447            +MEYER,PAULI, +       (SACLAY,COLFRANCE,RHEL)
DAUM     68 NP B7 19             +ERNE, LAGNAUX, SENS, STEUER, UDO     (CERN)JP
   CONFIRMS THE SPIN-PARITY ASSIGNMENT.
MULLER   69 THESIS,UCRL 19372 R A MULLER                              (LRL)

BERTHON1 70 NP B24 417           +VRANA, BUTTERWORTH, + (CDEF, RHEL, SACLAY)IJP
GALTIERI 70 DUKE CONF 173        A BARBARO-GALTIERI                    (LRL)IJP
LITCHFIE 71 NP  B30 125          LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP

BRANDSTE 72 NP B39 13            BRANDSTETTER+...+TALLINI   (RHEL,CDEF,SACL) IJP
KANE     72 PR D5 1583           D F KANE                              (LBL)IJP
RADER    73 NC 16A 178           +BARLOUTAUD,+     (SACL+HEID+CERN+RHEL+CDEF)

HEMINGWA 75 NP B91 12            HEMINGWAY,EADES,HARMSEN+   (CERN,HEID,MPIM)IJP
NAKKASYA 75 NP B93 85            A. NAKKASYAN                         (CERN)IJP
BACCARI  77 NC 41A 96            +POULARD,REVEL,TALLINI+          (SACL+CDEF)IJP
DECLAIS  77  CERN 77-16          +DUCHON,LOUVEL,PATRY,SEGUINOT+   (CAEN+CERN)IJP
RLIC     77 NP B119 362          GOPAL,ROSS,VAN HORN,MCPHERSON+   (LOIC+RHEL)IJP
BELLEFON 78 NC 42A 403           +BERTHON,BILLOIR,BRUNET+         (CDEF+SACL)IJP
CAMERON2 78 NP B146 327          +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
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Λ(2110) F''_{05}

35 Y*0(2110, JP=5/2+) I=0

```
            BERTHON1 70 FIND EITHER F05 OR D05 POSSIBLE IN
         THE SIG PI CHANNEL, WITH F05 SLIGHTLY PREFERRED.
         IN THE KBAR N CHANNEL, LITCHFIELD 71 (SAME GROUP)
         FIND ONLY D05. AS USUAL, THE STATISTICS ARE MUCH
         BETTER IN THE ELASTIC CHANNEL.
       ALTHOUGH KANE 72 FINDS AN F05 EFFECT, THE UNUSUALLY BROAD
   WIDTH MAY INVALIDATE A RESONANT INTERPRETATION.  HOWEVER RLIC 77,
   BELLEFON 77, AND BELLEFON 78 ALSO FIND AN F05. THE EVIDENCE FOR
   F05 FROM THE LAMBDA OMEGA ANALYSES, NAKKASYAN 75 AND BACCARI 77,
   IS QUITE WEAK, BUT THEY GIVE NO EVIDENCE IN FAVOR OF D05.  THE
   WEIGHT OF THE EVIDENCE IS THUS IN FAVOR OF F05.  SEE ALSO THE
   Y*0(2010) MINI-REVIEW.
```

35 Y*0(2110) MASS (MEV)

```
M         (2110.)    (10.)              BERTHON1  70 DPWA -  K- P TO SIG PI    1/71
M      D05 2140.      40.               LITCHFIE  71 DPWA    K-P TO KBAR N    10/71
M    A    (2141.0)    (6.0)             KANE      72 DPWA  O K-P TO PI SIG    10/71
M    A  RESONANCE OUTSIDE RANGE OF DATA.
M    1    (2103.)                       NAKKASYA  75 DPWA  O K-P TO LAM. OMG.  1/76
M    1  FOUND IN ONE OF TWO BEST SOLUTIONS.                                     1/76
M         (2137.)                       BACCARI   77 DPWA  O K-P TO LAM. OMG.  1/78
M         (2140.)    (20.)              BELLEFON  77 DPWA  O K- P TO SIG PI   11/77
M         (2100.)    (50.)              RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M    2    (2106.)    (50.)              BELLEFON  78 DPWA  O KBAR N TO KBAR N  1/78
M          2125.0     25.0              CAMERON2  78 DPWA    K-P TO K*(890) N 12/79*
```

35 Y*0(2110) WIDTH (MEV)

```
W         (185.)     (30.)              BERTHON1  70 DPWA -  K- P TO SIG PI    1/71
W      D05 120.       40.               LITCHFIE  71 DPWA    K-P TO KBAR N    10/71
W    A    (504.0)    (10.0)             KANE      72 DPWA  O K-P TO PI SIG    10/71
W    1    (391.)                        NAKKASYA  75 DPWA  O K-P TO LAM. OMG.  1/76
W         (132.)                        BACCARI   77 DPWA  O K-P TO LAM. OMG.  1/78
W         (140.)     (20.)              BELLEFON  77 DPWA  O K- P TO SIG PI   11/77
W         (200.)     (50.)              RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W    2    (251.)     (50.)              BELLEFON  78 DPWA  O KBAR N TO KBAR N  1/78
W          160.0      30.0              CAMERON2  78 DPWA    K-P TO K*(890) N 12/79*
```

35 Y*0(2110) PARTIAL DECAY MODES

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                                                           DECAY MASSES
P1      Y*0(2110) INTO KBAR N                               497+ 939
P2      Y*0(2110) INTO SIGMA PI                            1197+ 139
P3      Y*0(2110) INTO LAMBDA OMEGA                        1115+ 782
P4      Y*0(2110) INTO Y*1(1385) PI P-WAVE                  139+1384
P5      Y*0(2110) INTO N K*(890), F1 WAVE                   939+ 892
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35 Y*0(2110) BRANCHING RATIOS

```
R1      Y*0(2110) FROM KBAR N TO SIGMA PI                     SQRT(P1*P2)
R1          (+.17)     (.03)            BERTHON1  70 DPWA -  K- P TO SIG PI    1/71
R1   A     (+0.156)   (0.013)           KANE      72 DPWA  O K-P TO PI SIG    10/71
R1          (+.14)     (.01)            BELLEF02  76 DPWA  O K- P TO SIG PI    1/76
R1          (+.10)     (.03)            RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R2      Y*0(2110) INTO (KBAR N)/TOTAL                         (P1)
R2      D05   0.14      0.04            LITCHFIE  71 DPWA    K-P TO KBAR N    10/71
R2           (.07)     (.03)            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R2   2       (.27)     (.06)            BELLEFON  78 DPWA  O KBAR N TO KBAR N  1/78
R2   2  THE PUBLISHED ERROR OF 0.6 WAS A MISPRINT.                             12/79*

R3      Y*0(2110) FROM KBAR N INTO LAMBDA OMEGA               SQRT(P1*P3)       1/76
R3   1       (.112)                     NAKKASYA  75 DPWA  O K-P TO LAM. OMG.  1/76
R3        LESS THAN .05                 BACCARI   77 DPWA  O K-P TO LAM. OMG.  1/78

R4      Y*0(2110) FROM KBAR N TO Y*1(1385) PI P-WAVE      SQRT(P1*P4)
R4   2       +.071     .025             CAMERON   78 DPWA  O K-P TO S(1385)PI  1/78
R4   2  CAMERON  78 UPPER LIMIT ON F-WAVE DECAY IS 0.03.  THE SIGN HERE IS     12/79*
R4   2  CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.              12/79*

R5      Y*0(2110) FROM KBAR N INTO N K*(890), F1 WAVE    SQRT(P1*P5)
R5   3      -0.17      0.04             CAMERON2  78 DPWA    K-P TO K*N       12/79*
R5   3  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST         12/79*
R5   3  CONVENTION.  UPPER LIMITS ON THE P3 AND F3 WAVES ARE EACH 0.03.        12/79*
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REFERENCES FOR Y*0(2110)


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BERTHON1 70 NP B24 417           +VRANA,BUTTERWORTH,+       (CDEF,RHEL,SACLAY)IJP
LITCHFIE 71 NP  B30 125          LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
KANE     72 PR D5 1583           D F KANE                              (LBL)IJP

NAKKASYA 75 NP B93 85            A. NAKKASYAN                         (CERN)IJP
BACCARI  77 NC 41A 96            +POULARD,REVEL,TALLINI+          (SACL+CDEF)IJP
BELLEFON 77 NC 37A 175           DE BELLEFON,BERTHON,BILLOIR+     (CDEF+SACL)IJP
RLIC     77 NP B119 362          GOPAL,ROSS,VAN HORN,MCPHERSON+   (LOIC+RHEL)IJP
BELLEFON 78 NC 42A 403           +BERTHON,BILLOIR,BRUNET+         (CDEF+SACL)IJP
CAMERON  78 NP B143 189          +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327          +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
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Baryons
Λ(2110), Λ(2325), Λ(2350)

Data Card Listings
For notation, see key at front of Listings.

2100 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

25 Y*0(2100, JP=) I=0 PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

SEE THE NOTE TO THE G07 Y*0(2100), WHICH PRECEDES THIS ENTRY. HERE WE LIST ONLY PARAMETERS OF PEAKS IN CROSS SECTIONS AND INVARIANT-MASS DISTRIBUTIONS. THE CROSS-SECTION PEAKS ARE AT LEAST DOMINANTLY ASSOCIATED WITH THE Y*0(2100), BUT MAY CONTAIN A SMALL CONTRIBUTION FROM THE SUGGESTED BUT NOT ESTABLISHED OTHER RESONANCES IN THIS REGION.

25 Y*0(2100) MASS (MEV) (PROD. EXP.)

M	(2097.0)	(6.0)		BOCK	65 HBC	PBAR P 5.7 BEV/C	7/66
M	2100.0	(7.0)		BUGG	68 CNTR	K-P, D TOTAL	6/68
M	2121.0	(5.0)		BRICMAN	70 CNTR	0 TOTAL AND CH EX	6/70
M	2107.0	(10.0)		COOL	70 CNTR	K-P, D TOTAL	10/70
M	(2135.0)	(20.0)		LU	70 CNTR	0 GAMMA P TO K+ Y*	1/71

25 Y*0(2100) WIDTH (MEV) (PROD. EXP.)

W	(24.0)	(14.0)	(24.0)	BOCK	65 HBC	INTO KBAR N (PI)	7/66
W	140.0	(15.0)		BUGG	68 CNTR		6/68
W	147.0	(15.0)		BRICMAN	70 CNTR	0 TOTAL AND CH EX	6/70
W	185.0			COOL	70 CNTR	K-P, D TOTAL	10/70
W	(40.0)			LU	70 CNTR	0 GAMMA P TO K+ Y*	1/71

25 Y*0(2100) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	Y*0(2100) INTO KBAR N	497+ 939
P2	Y*0(2100) INTO KBAR N PI	497+ 939+ 139
P3	Y*0(2100) INTO LAMBDA ETA	1115+ 548
P4	Y*0(2100) INTO LAMBDA OMEGA	1115+ 782

25 Y*0(2100) BRANCHING RATIOS (PROD. EXP.)

R1	Y*0(2100) INTO (KBAR N)/TOTAL				(P1)	
R1	THESE VALUES OF ELASTICITIES ASSUME J=7/2 --					
R1	0.305		BUGG	68 CNTR		6/68
R1	0.24	(0.02)	BRICMAN	70 CNTR	0 TOTAL AND CH EX	6/70
R1	0.4		COOL	70 CNTR	K-P, D TOTAL	10/70
R2	Y*0(2100) INTO KBAR N PI				(P2)	
R2	SEEN		BOCK	65 HBC		
R3	Y*0(2100) FROM KBAR N INTO LAMBDA ETA				SQRT(P1*P3)	
R3	(0.09) OR LESS		FLATTE 2	67 HBC	0 K-P TO LAM ETA	6/68
R4	Y*0(2100) INTO (LAMBDA OMEGA)/TOTAL				(P4)	
R4	(0.1) OR LESS		FLATTE 1	67 HBC	0 K-P TO LAM OMEGA	8/67

REFERENCES FOR Y*0(2100) (PROD. EXP.)

BOCK 65 PL 17 166 +COOPER,FRENCH,KINSON, + (CERN,SACLAY)
FLATTE 1 67 PR 155 1517 S M FLATTE (LRL)
FLATTE 2 67 PR 163 1441 S M FLATTE, C G WOHL (LRL)
BUGG 68 PR 168 1466 +GILMORE,KNIGHT, + (RHEL,BIRM,CAVE) I

BRICMAN 70 PL 31B 152 +FERRO LUZZI, PERREAU,+ (CERN,CAEN,SACLAY)
COOL 70 PR D1 1887 +GIACOMELLI, KYCIA, LEONTIC, LI, + (BNL) I
LU 70 PR D2 1846 +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

PAPERS NOT REFERRED TO IN DATA CARDS

COOL 66 PRL 16 1228 +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
SUPERSEDED BY COOL 70.

Λ(2325)

112 Y*0(2325, JP=3/2-) I=0 D''_{03}

→ BACCARI 77 FIND THIS STATE WITH JP EITHER 3/2- OR 3/2+ IN A DPWA OF K- P TO LAMBDA OMEGA FROM 2070 TO 2436 MEV. A SUBSEQUENT SEMI-ENERGY-INDEPENDENT PWA FROM THRESHOLD TO 2436 MEV SELECTS 3/2-. BELLEFON 78 (SAME GROUP) ALSO SEE THIS STATE IN A DPWA OF K- P ELASTIC AND CHARGE-EXCHANGE DATA IN THE SAME ENERGY RANGE, AND FIND JP=3/2- OR 3/2+. THEY AGAIN PREFER JP=3/2-, BUT ONLY ON THE BASIS OF MODEL DEPENDENT CONSIDERATIONS.

112 Y*0(2325) MASS (MEV)

M	3	2327.	20.	BACCARI	77 DPWA	0 K-P TO LAM. OMG.	1/78
M		2342.	30.	BELLEFON	78 DPWA	0 KBAR N TO KBAR N	1/78
M		. . . .					
M	AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)						

112 Y*0(2325) WIDTH (MEV)

W	3	160.	40.	BACCARI	77 IPWA	0 K-P TO LAM. OMG.	1/78
W		177.	40.	BELLEFON	78 DPWA	0 KBAR N TO KBAR N	1/78
W		. . . .					
W	AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)						

112 Y*0(2325) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*0(2325) INTO KBAR N	497+ 939
P2	Y*0(2325) INTO LAMBDA OMEGA	1115+ 782

112 Y*0(2325) BRANCHING RATIOS

R1		Y*0(2325) FROM KBAR N TO LAMBDA OMEGA				SQRT(P1*P2)	
R1	3	.06	.02	BACCARI	77 IPWA	0 DS33-WAVE	1/78
R1	3	.05	.02	BACCARI	77 DPWA	0 DD13-WAVE	1/78
R1	3	.08	.03	BACCARI	77 DPWA	0 DD33-WAVE	1/78
R1	3	NOTE THAT THE 3 ENTRIES FOR BACCARI77 ARE FOR 3 DIFFERENT WAVES.					1/78
R1		. . . .					
R1		AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)					
R2		Y*0(2325) INTO (KBAR N)/TOTAL				P1	
R2		.19	.06	BELLEFON	78 DPWA	0 KBAR N TO KBAR N	1/78

REFERENCES FOR Y*0(2325)

BACCARI 77 NC 41A 96 +POULARD,REVEL,TALLINI+ (SACL+CDEF)IJP
BELLEFON 78 NC 42A 403 +BERTHON,BILLOIR,BRUNET+ (CDEF+SACL)IJP

Λ(2350) BUMPS

42 Y*0(2350, JP=) I=0 PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

DAUM 68 FAVORS JP=7/2- OR 9/2+. BRICMAN 70 FAVORS 9/2+. LASINSKI 71 SUGGESTS THREE STATES IN THIS REGION USING A POMERON + RESONANCES MODEL. THERE ARE NOW ALSO THREE FORMATION EXPERIMENTS FROM THE COLLEGE DE FRANCE-SACLAY GROUP WHICH WE INCLUDE HERE, BELEFON 77, BACCARI 77, AND BELLEFON 78, WHICH FIND 9/2+ IN DPWAS OF KBAR N TO SIGMA PI, LAMBDA CMEGA, AND KBAR N.

42 Y*0(2350) MASS (MEV) (PROD. EXP.)

M	2340.0	(7.0)	BUGG	68 CNTR	K-P, D TOTAL	6/68
M	2358.0	(6.0)	BRICMAN	70 CNTR	0 TOTAL AND CH EX	6/70
M	2344.0	(15.0)	COOL	70 CNTR	K-P, D TOTAL	10/70
M	(2360.0)	(20.0)	LU	70 CNTR	0 GAMMA P TO K+ Y*	1/71
M	(2372.)		BACCARI	77 DPWA	0 K-P TO LAM. OMG.	1/78
M	2365.	20.	BELLEFON	77 DPWA	0 K- P TO SIG PI	11/77
M	2370.	50.	BELLEFON	78 DPWA	0 KBAR N TO KBAR N	1/78
M	. . . .					
M	AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)					

42 Y*0(2350) WIDTH (MEV) (PROD. EXP.)

W	140.0	(20.0)	BUGG	68 CNTR	K-P, D TOTAL	6/68
W	324.0	(30.0)	BRICMAN	70 CNTR	0 TOTAL AND CH EX	6/70
W	(190.0)		COOL	70 CNTR	K-P, D TOTAL	10/70
W	(55.0)		LU	70 CNTR	0 GAMMA P TO K+ Y*	1/71
W	(257.)		BACCARI	77 DPWA	0 K-P TO LAM. OMG.	1/78
W	110.	20.	BELLEFON	77 DPWA	0 K- P TO SIG PI	11/77
W	204.	50.	BELLEFON	78 DPWA	0 KBAR N TO KBAR N	1/78
W	. . . .					
W	AVERAGE MEANINGLESS (SCALE FACTOR = 1.7)					

42 Y*0(2350) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	Y*0(2350) INTO KBAR N	497+ 939
P2	Y*0(2350) INTO SIGMA PI	1197+ 139
P3	Y*0(2350) INTO LAMBDA OMEGA	1115+ 782

42 Y*0(2350) BRANCHING RATIOS (PROD. EXP.)

R1	Y*0(2350) INTO (KBAR N)/TOTAL				(P1)	
R1	.12	.04	BELLEFON	78 DPWA	0 KBAR N TO KBAR N	1/78
R2	Y*0(2350) FROM KBAR N INTO SIGMA PI				SQRT(P1*P2)	1/76
R2	-.11	.02	BELLEFON	77 DPWA	0 K- P TO SIG PI	11/77
R3	Y*0(2350) FROM KBAR N TO LAMBDA OMEGA				SQRT(P1*P3)	1/78
R3	LESS THAN .05		BACCARI	77 DPWA	0 K-P TO LAM. OMG.	1/78
R4	Y*0(2350) INTO (KBAR N)/TOTAL				(J+1/2)*(P1)	
R4	J IS NOT DETERMINED IN THESE EXPTS. THE FOLLOWING IS (J+1/2)*P1					
R4	(0.57)		BUGG	68 CNTR	K-P, D TOTAL	3/78
R4	1.1	0.25	BRICMAN	70 CNTR	0 TOTAL AND CH EX	3/78
R4	(1.0)		COOL	70 CNTR	K-P, D TOTAL	3/78

REFERENCES FOR Y*0(2350) (PROD. EXP.)

BUGG 68 PR 168 1466 +GILMORE,KNIGHT, + (RHEL,BIRM,CAVE) I
DAUM 68 NP B7 19 +ERNE, LAGNAUX, SENS, STEUER, UDO (CERN)JP
BRICMAN 70 PL 31B 152 +FERRO LUZZI, PERREAU,+ (CERN,CAEN,SACLAY)
COOL 70 PR D1 1887 +GIACOMELLI, KYCIA, LEONTIC, LI, + (BNL) I
LU 70 PR D2 1846 +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

BACCARI 77 NC 41A 96 +POULARD,REVEL,TALLINI+ (SACL+CDEF)IJP
BELLEFON 77 NC 37A 175 DE BELLEFON,BERTHON,BILLOIR+ (CDEF+SACL)IJP
BELLEFON 78 NC 42A 403 +BERTHON,BILLOIR,BRUNET+ (CDEF+SACL)IJP

PAPERS NOT REFERRED TO IN DATA CARDS

COOL 66 PRL 16 1228 +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
SUPERSEDED BY COOL 70.
LASINSKI 71 NP B29 125 T A LASINSKI (EFI)IJP
BELLEFO2 75 NC 28A 289 DE BELLEFON,BERTHON,BILLOIR+ (CDEF+SACL)
PRESENTLY LISTED UNDER Y*1(2250), BUT ISOSPIN UNDETERMINED.

Data Card Listings

For notation, see key at front of Listings.

Baryons

Λ(2585), Σ⁺, Σ⁻, Σ⁰, Σ(1385)

Λ(2585) BUMPS

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7  Y*0(2585, JP=    ) I=0          PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

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              7  Y*0(2585) MASS (MEV) (PROD. EXP.)

M        2585.0      45.0             ABRAMS     70 CNTR   K-P, D TOTAL     10/70
M       (2530.0)   (25.0)             LU         70 CNTR  0 GAMMA P TO K+ Y*  1/71

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              7  Y*0(2585) WIDTH (MEV) (PROD. EXP.)

W       (300.0)                       ABRAMS     70 CNTR   K-P, D TOTAL     10/70
W       (150.0)                       LU         70 CNTR  0 GAMMA P TO K+ Y*  1/71

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              7  Y*0(2585) PARTIAL DECAY MODES (PROD. EXP.)

                                                         DECAY MASSES
P1     Y*0(2585) INTO KBAR N                             497+ 939

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              7  Y*0(2585) BRANCHING RATIOS (PROD. EXP.)

R1     Y*0(2585) INTO (KBAR N)/TOTAL                    (P1)
R1        J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1          (1.0)                     ABRAMS     70 CNTR   K-P, D TOTAL     10/70
R1  C       (0.12)   (0.12)           BRICMAN    70 CNTR   TOTAL AND CH EX  10/70
R1  C    RESONANCE AT END OF REGION ANALYZED -- NO CLEAR SIGNAL.

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                         REFERENCES FOR Y*0(2585) (PROD. EXP.)

ABRAMS    70 PR 1D 1917        +COOL, GIACOMELLI, KYCIA, LEONTIC, +  (BNL) I
BRICMAN   70 PL 31B 152        +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
LU        70 PR D2 1846        +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

                         PAPERS NOT REFERRED TO IN DATA CARDS

COOL      66 PRL 16 1228       +GIACOMELLI,KYCIA,LEONTIC,LUNDBY +    (BNL)I

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S=−1 I=1 HYPERON STATES (Σ)

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Σ⁻

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19  SIGMA+(1189, JP=1/2+) I=1

SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ⁺

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20  SIGMA-(1198, JP=1/2+) I=1

SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ⁰

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21  SIGMA0(1193, JP=1/2+) I=1

SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ(1385) **P′₁₃**

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43  Y*1(1385, JP=3/2+) I=1

SERIOUS INCOMPATIBILITIES EXIST BETWEEN DIFFERENT
MEASUREMENTS OF THE Y*(1385) MASS AND WIDTH. THESE
INCOMPATIBILITIES ARE AT LEAST PARTIALLY ACCOUNTED FOR
BY SOME EXPERIMENTS QUOTING UNREALISTICALLY SMALL
ERRORS. WE CONSISTENTLY INCREASE UNREALISTIC ERRORS BEFORE AVERAGING
(SEE THE TYPED NOTE ON K*(892)).
IN THE LISTINGS BELOW WE ATTEMPT TO OBTAIN THE BEST VALUES FOR THE
SEPARATE CHARGE STATE MASSES AND WIDTHS. THUS WE DO NOT USE RESULTS
QUOTED FOR MIXED CHARGES.
WE NO LONGER USE EVERY PUBLISHED VALUE, BUT AVERAGE ONLY THE MOST
SIGNIFICANT DETERMINATIONS. NEITHER DO WE AVERAGE RESULTS FROM
INCLUSIVE EXPERIMENTS WITH LARGE BACKGROUNDS OR RESULTS WHICH ARE NOT
ACCOMPANIED BY AT LEAST A DISCUSSION ON EXPERIMENTAL RESOLUTION.
NEVERTHELESS SYSTEMATIC DIFFERENCES BETWEEN EXPERIMENTS REMAIN (SEE
THE IDEOGRAMS INSERTED IN THE DATA CARD LISTINGS BELOW). THESE
DIFFERENCES COULD ARISE FROM INTERFERENCE EFFECTS THAT CHANGE WITH
PRODUCTION MECHANISM AND/OR BEAM MOMENTUM. THEY CAN ALSO BE ACCOUNTED
FOR IN PART BY DIFFERENCES IN THE PARAMETRIZATIONS EMPLOYED (SEE
BORENSTEIN 74 FOR A DISCUSSION ON THIS POINT). THUS BORENSTEIN 74 USE A
BREIT-WIGNER WITH ENERGY INDEPENDENT WIDTH, SINCE A P-WAVE WAS FOUND
TO GIVE UNSATISFACTORY FITS. CAMERON 78 USE THE SAME FORM.
ON THE OTHER HAND HOLMGRAN 77 OBTAIN A GOOD FIT TO THEIR LAMBDA PI MASS
SPECTRUM WITH A P-WAVE BREIT-WIGNER, BUT INCLUDE THE PARTIAL WIDTH FOR
THE SIGMA PI DECAY MODE IN THE PARAMETRIZATION.

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              43  Y*1(1385) MASS (MEV)

M        141(1384.0)                  ALSTON     60 HBC  +- K-P 1.15 BEV/C
M           (1385.0)                  BERGE      61 HBC  +- K-P .4-.85 BEV/C
M         38(1384.0)                  MARTIN     61 HBC  +0 K20 P .98 BEV/C
M           (1392.0)     (7.0)        COLLEY     62 HLBC -0 PI- PRP 2. BEV/C
M           (1389.0)     (3.0)        BALTAY     65 HBC  +- PBAR P 3.7 BEV/C  7/66
M           (1392.0)    (10.0)        MUSGRAVE   65 HBC  +-OPBAR P 3-4 BEV/C  7/66
M        200(1384.8)     (2.0)        ATHERTON   71 HBC  +- LAM PI+ + C.C.   11/77
M        190(1380.)      (5.)         AMMANN     73 DBC  +- K-N 4.5GEV/C     11/77
M        200(1386.)                   ATHERT01   75 HBC  +-OPBAR P 5.7 GEV/C  1/76
M        242(1394.)      (5.)         DIONISI    78 HBC  +- K-P TO Y* K KBAR  3/79*
M    I    1K(1383.)      (1.)         BANERJEE   79 HBC  +- LAM PI+ + C.C.    1/80*
M    I   500(1388.)      (2.)         BANERJEE   79 HBC  +- LAM PI- + C.C.    1/80*
M    I    FROM FIT TO INCLUSIVE LAMBDA PI + C.C. SPECTRA
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MO       106(1381.0)     (4.0)        CURTIS     63 OSPK   0 PI-P 1.5 BEV/C
MO E     240 1385.1       2.5         THOMAS     73 HBC    0 PI-P TO PIOKOLM  11/77
MO E      ERROR ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
MO 2    3100 1380.        2.          BORENSTE   74 HBC    0 K-P TO(1385)+PIS 11/77
MO 2      FROM FIT TO LAM PIO MASS SPECTRUM (IN LAM PI+ PI- PIO EVENTS) WITH
MO 2      WO FIXED AT 34 MEV.
MO  F    500(1389.)      (3.)         BAUBILLIE  79 HBC    0 K-P AT 8.25 GEV   1/80*
MO            . . . . . . . . . . .
MO  AVG     1382.0        2.5      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
MO  STUDENT1381.9         1.9      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
MO  F     FROM FIT TO INCLUSIVE LAMBDA PIO SPECTRUM WITH WIDTH FIXED AT
MO  F     40 MEV.

M+ E     154(1376.0)     (3.9)        ELY        61 HLBC +  K-P 1.11 BEV/C     11/77
M+       170(1375.0)     (3.9)        COOPER     64 HBC  +  K-P 1.45 BEV/C     11/77
M+       859 1381.0       1.6         HUWE       64 HBC  +  K-P 1.22 BEV/C
M+       750 1382.0       1.0         ARMENTERO  65 HBC  +  K-P .9-1.2 BEV/C
M+ E     250(1384.3)     (1.9)        SMITH      65 HBC  +  K-P 1.8 BEV/C      11/77
M+ E     250(1382.6)     (2.1)        SMITH      65 HBC  +  K-P 1.95 BEV/C     11/77
M+ E      62(1383.0)     (8.0)        BIRMINGHA  66 HBC  +  K-P 3.5 GEV/C      11/77
M+       135(1378.0)     (5.0)        LONDON     66 HBC  +  K-P 2.24 BEV/C     11/77
M+      1260 1384.4       1.0         SIEGEL     67 HBC  +  K-P AT 2.1 GEV/C 10/69
M+        46(1390.0)     (6.0)        AGUILAR    70 HBC  +  K-P 4 GEV/SIG.PI 11/77
M+       400 1382.0       2.0         AGUILAR    72 HBC  +  K-P TO LAM+PIS   10/74
M+      2300 1383.5        .85        HABIBI     73 HBC  +  K-P TO 2PI LAM    9/73
M+   R 3740(1382.)       (1.)         BERTHON    74 HBC  +  K-P 1263-1843MEV 10/74
M+   R    ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
M+      6846 1381.        1.          BORENSTE   74 HBC  +  K-P TO(1385)+PIS 10/74
M+   I      (1380.)      (2.)         BARDADIN   75 HBC  +  K- P 14.3 GEV/C  11/77
M+ HI    22K(1385.)      (3.)         BARREIRO   77 HBC  +  K-P AT 4.2 GEV   11/77
M+ H      INCLUDES DATA OF HOLMGREN 77
M+      2594 1385.        1.          HOLMGREN   77 HBC  +  K-P AT 4.2 GEV   11/77
M+      6900 1381.9       0.3         CAMERON    78 HBC  +  K-P 0.96-1.36GEV 11/77
M+   I    7K(1381.)      (2.)         BAUBILLIE  79 HBC  +  K-P AT 8.25 GEV   1/80*
M+        2K(1391.)      (2.)         CAUTIS     79 HYBR +  PI+/K-P 11.5 GEV  1/80*
M+   I   100(1390.)      (2.)         SUGAHARA   79 HBC  +  PI-P AT 6 GEV/C   1/80*
M+
M+   I    FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
M+ E      ERROR ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
M+            . . . . . . . . .
M+  AVG     1382.29       0.39     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
M+  STUDENT1382.20        0.31     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                          (SEE IDEOGRAM BELOW )
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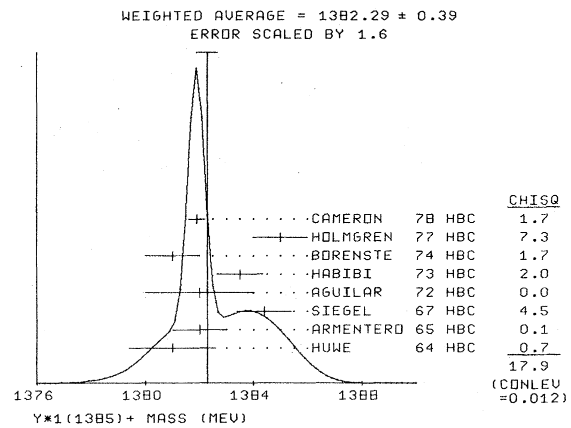


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M-        93(1382.0)     (3.0)        DAHL       61 DBC  -  K-D 0.45 BEV/C     11/77
M- E     224(1376.0)     (4.4)        ELY        61 HLBC -  K-P 1.11 BEV/C     11/77
M-       200(1392.0)     (6.2)        COOPER     64 HBC  -  K-P 1.45 BEV/C     11/77
M- E    1086 1385.3       1.9         HUWE       64 HBC  -  K-P 1.15-1.30GEV 11/77
M-      1380 1384.0       1.0         ARMENTERO  65 HBC  -  K-P .9-1.2 BEV/C
M- E     120(1391.5)     (2.6)        SMITH      65 HBC  -  K-P 1.8 BEV/C      11/77
M- E      58(1399.8)     (2.2)        SMITH      65 HBC  -  K-P 1.95 BEV/C     11/77
M-        15(1389.0)     (9.0)        LONDON     66 HBC  -  K-P AT 2.24 GEV  11/77
M-       370 1390.7       2.0         SIEGEL     67 HBC  -  K-P AT 2.1 GEV/C 10/69
M-      1900 1390.7       1.2         HABIBI     73 HBC  -  K-P TO 2PI LAM    9/73
M- E     630 1387.1       1.9         THOMAS     73 HBC  -  PI-P TO PI-K+LM  11/77
M-   R 3060(1389.)       (1.)         BERTHON    74 HBC  -  K-P 1263-1843MEV 10/74
M-   R    ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
M-      2303 1383.        2.          BORENSTE   74 HBC  -  K-P TO(1385)+PIS 10/74
M-   I      (1383.)      (2.)         BARDADIN   75 HBC  -  K- P 14.3 GEV/C  11/77
M- HI    12K(1387.)      (3.)         BARREIRO   77 HBC  -  K-P AT 4.2 GEV   11/77
M- H      INCLUDES DATA OF HOLMGREN 77
M-       193 1391.        3.          HOLMGREN   77 HBC  -  K-P AT 4.2 GEV   11/77
M-      9720 1387.6       0.3         CAMERON    78 HBC  -  K-P 0.96-1.36GEV 11/77
M-   I 4.5K(1383.)       (1.)         BAUBILLIE  79 HBC  -  K-P AT 8.25 GEV   1/80*
M-   I   150(1380.)      (6.)         SUGAHARA   79 HBC  -  PI-P AT 6 GEV/C   1/80*
M-
M-   I    FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
M- E      ERROR ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
M-            . . . . . . . . . .
M-  AVG     1387.44       0.58     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
M-  STUDENT1387.53        0.31     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                          (SEE IDEOGRAM BELOW )
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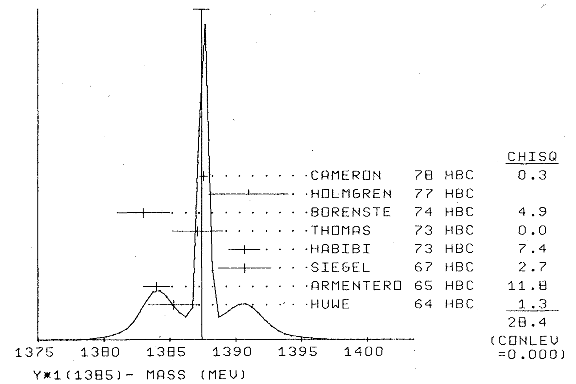
Baryons
Σ(1385)

Data Card Listings
For notation, see key at front of Listings.

WEIGHTED AVERAGE = 1387.44 ± 0.58
ERROR SCALED BY 2.2

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             43   (Y*-) - (Y*+) MASS DIFFERENCE (MEV)

D-+ R        (0.0)     (4.2)            ELY        61 HLBC +- K-P 1.11 BEV/C      8/66
D-+ R       (17.)      (7.)             COOPER     64 HBC  +- K-P 1.45 BEV/C     10/69
D-+ R        (4.3)     (2.2)            HUWE       64 HBC  +- K-P 1.22 BEV/C      8/66
D-+ R        (2.0)     (1.5)            ARMENTERO  65 HBC  +- K-P .9-1.2 BEV/C    8/66
D-+ R        (7.2)     (2.1)            SMITH      65 HBC  +- K-P 1.8 BEV/C       9/66
D-+ R       (17.2)     (2.0)            SMITH      65 HBC  +- K-P 1.95 BEV/C      9/66
D-+ R       (11.0)     (9.0)            LONDON     66 HBC  +- K-P 2.24 BEV/C      8/66
D-+           9.0       6.0             LONDON     66 HBC  +- LAMBDA 3 PI EVTS    7/66
D-+ R        (6.3)     (2.0)            SIEGEL     67 HBC  +- K-P AT 2.1 GEV/C 10/69
D-+ R        (7.2)     (1.4)            HABIBI     73 HBC  +- K-P TO 2PI LAM      9/73
D-+ R      BETWEEN -2 AND +6 CL=.95     BORENSTE   74 HBC  +- K-P TO(1385)+PIS 11/77
D-+
D-+ R   REDUNDANT WITH DATA IN MASS LISTINGS

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             43   (Y*0) - (Y*+) MASS DIFFERENCE (MEV)

DO+ R      BETWEEN -4 AND +4 CL=.95    BORENSTE   74 HBC   +0 K-P TO(1385)+PIS 11/77
DO+ R   REDUNDANT WITH DATA IN MASS LISTINGS

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             43   (Y*-) - (Y*0) MASS DIFFERENCE (MEV)

D-0 R        (2.0)     (2.4)            THOMAS     73 HBC  -0 PI-P TO PI-K+LM  11/77
D-0 R   REDUNDANT WITH DATA IN MASS LISTINGS

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             43   Y*1(1385) WIDTH (MEV)

W         141  (64.0)                   ALSTON     60 HBC  +- K-P 1.15 BEV/C
W              (40.0)                   BERGE      61 HBC  +- K-P .4-.85 BEV/C
W          38  (20.0)  OR LESS          MARTIN     61 HBC  +0 K20 P .98 BEV/C
W              (80.0)   (10.0)          COLLEY     62 HLBC -0 PI- PRP 2. BEV/C
W              (26.0)    (5.0)          BALTAY     65 HBC  +- PBAR P 3.7 BEV/C   7/66
W              (38.0)    (9.0)          MUSGRAVE   65 HBC  +-OPBAR P 3-4 BEV/C   7/66
W       T 200  (20.)     (4.)           ATHERTON   71 HBC  +- LAM PI+ + C.C.    11/77
W       T  FIT B.W. + PHASE SPACE BCKGRD
W       R 200  (35.)     (5.)           ATHERTON   71 HBC  +- LAM PI+ + C.C.    11/77
W       R  FIT B.W. AND NO BCKGRD
W         190  (61.)    (10.)           AMMANN     73 DBC  +- K-N 4.5GEV/C      11/77
W         200  (89.)    (23.)           ATHERTON1  75 HBC  +-OPBAR P 5.7 GEV/C 11/77
W     D        (20.)    (10.)           ALSTON     78 DPWA -0 KBAR N ONLY        1/78
W     D    WITH MASS FIXED AT 1385 MEV.  FROM RESULTS OF PARTIAL WAVE ANALYSIS   1/78
W     D    OF KBAR N SYSTEM EXTRAPOLATED BELOW THRESHOLD.                        1/78
W         242  (53.)    (14.)           DIONISI    78 HBC  +- K-P TO Y* K KBAR  3/79*
W     I    1K  (35.)     (2.)           BANERJEE   79 HBC  +- LAM PI+ + C.C.    1/80*
W     I   500  (36.)     (4.)           BANERJEE   79 HBC  +- LAM PI- + C.C.    1/80*
W     I    FROM FIT TO INCLUSIVE LAMBDA PI + C.C. SPECTRA

WO        106  (30.0)    (9.0)          CURTIS     63 OSPK  0 PI-P 1.5 BEV/C
WO  E     240   39.3     10.2           THOMAS     73 HBC   0 PI-P TO PIOKOLM   11/77
WO  E      ERROR ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
WO    C 3100   (53.)     (8.)           BORENSTE   74 HBC   0 K-P TO(1385)+PIS 11/77
WO    C 3100 CONSISTENT WITH WO=W+=W-   BORENSTE   74 HBC   0 K-P TO(1385)+PIS 11/77

W+  E     154  (48.0)   (16.0)          ELY        61 HLBC +  K-P 1.11 BEV/C     11/77
W+  E     170  (51.0)   (16.0)          COOPER     64 HBC  +  K-P 1.45 BEV/C     11/77
W+  E     859   46.5      6.4           HUWE       64 HBC  +  K-P 1.15-1.30GEV 11/77
W+  E     750   32.0      4.7           ARMENTERO  65 HBC  +  K-P .95-1.20 GEV 11/77
W+  E     250  (30.3)    (7.5)          SMITH      65 HBC  +  K-P 1.8 BEV/C      11/77
W+  E     250  (33.1)    (8.3)          SMITH      65 HBC  +  K-P 1.95 BEV/C     11/77
W+  E      62  (25.0)   (32.0)          BIRMINGHA  66 HBC  +  K-P 3.5 GEV/C      11/77
W+  E    1260   36.0      4.0           SIEGEL     67 HBC  +  K-P AT 2.1 GEV/C 11/77
W+  E      46  (33.)    (20.0)          AGUILAR    70 HBC  +  K-P 4 GEV/SIG.PI 11/77
W+        400   32.5      6.0           AGUILAR    72 HBC  +  K-P TO LAM+PIS    10/74
W+  E    2300   38.3      3.2           HABIBI     73 HBC  +  K-P TO 2PI LAM    11/77
W+    R  3740  (48.)     (3.)           BERTHON    74 HBC  +  K-P 1263-1843MEV 10/74
W+    R    ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
W+  1    6846   34.       1.6           BORENSTE   74 HBC  +  K-P TO(1385)+PIS 11/77
W+  1   RESULTS FROM LAM PI+ PI- AND LAM PI+ PI- PIO COMBINED BY US.
W+   I         (40.)     (3.2)          BARDADIN   75 HBC  +  K- P 14.3 GEV/C   11/77
W+  HI    22K  (43.)     (5.)           BARREIRO   77 HBC  +  K-P AT 4.2 GEV    11/77
W+  H      INCLUDES DATA OF HOLMGREN 77
W+       2594   34.       2.            HOLMGREN   77 HBC  +  K-P AT 4.2 GEV    11/77
W+       6900   35.5      1.9           CAMERON    78 HBC  +  K-P 0.96-1.36GEV 11/77
W+   I     7K  (37.)     (2.)           BAUBILLIE  79 HBC  +  K-P AT 8.25 GEV   1/80*
W+         2K  (30.)     (4.)           CAUTIS     79 HYBR +  PI+/K-P 11.5 GEV  1/80*
W+   I    100  (30.)     (6.)           SUGAHARA   79 HBC  +  PI-P AT 6 GEV/C   1/80*
W+
W+   I     FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
W+  E      ERROR ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
W+              . . . . . . . . .
W+   AVG        34.96     0.92    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W+   STUDENT    34.9      1.0     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W-             (40.0)                   DAHL       61 DBC  -  K-D 0.45 BEV/C
W-  E     224  (66.0)   (18.0)          ELY        61 HLBC -  K-P 1.11 BEV/C     11/77
W-  E     200  (88.0)   (24.0)          COOPER     64 HBC  -  K-P 1.45 BEV/C     11/77
W-       1086   62.0      7.0           HUWE       64 HBC  -  K-P 1.15-1.30GEV
W-  E    1382   38.0      4.1           ARMENTERO  65 HBC  -  K-P .95-1.20 GEV 11/77
W-  E     120  (29.2)   (10.6)          SMITH      65 HBC  -  K-P 1.80 BEV/C     11/77
W-  E      58  (17.1)    (8.9)          SMITH      65 HBC  -  K-P 1.95 BEV/C     11/77
W-  E     370   31.0      6.5           SIEGEL     67 HBC  -  K-P AT 2.1 GEV/C 11/77
W-  E    1900   51.9      4.8           HABIBI     73 HBC  -  K-P TO 2PI LAM    11/77
W-  E     630   48.2      7.7           THOMAS     73 HBC  -  PI-P TO PI-KOLM   11/77
W-    R  3060  (40.)     (3.)           BERTHON    74 HBC  -  K-P 1263-1843MEV 10/74
W-    R    ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
W-  1    2303   35.       3.            BORENSTE   74 HBC  -  K-P TO(1385)+PIS 11/77
W-  1   RESULTS FROM LAM PI+ PI- AND LAM PI+ PI- PIO COMBINED BY US.
W-   I         (47.)     (6.)           BARDADIN   75 HBC  -  K- P 14.3 GEV/C   11/77
W-  HI    12K  (45.)     (5.)           BARREIRO   77 HBC  -  K-P AT 4.2 GEV    11/77
W-  H      INCLUDES DATA OF HOLMGREN 77
W-        193  (35.)    (10.)           HOLMGREN   77 HBC  -  K-P AT 4.2 GEV    11/77
W-       9720   39.2      1.7           CAMERON    78 HBC  -  K-P 0.96-1.36GEV 11/77
W-   I   4.5K  (44.)     (4.)           BAUBILLIE  79 HBC  -  K-P AT 8.25 GEV   1/80*
W-   I    150  (58.)     (4.)           SUGAHARA   79 HBC  -  PI-P AT 6 GEV/C   1/80*
W-
W-   I     FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
W-  E      ERROR ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
W-              . . . . . . . . .
W-   AVG        39.9      2.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
W-   STUDENT    39.4      1.5     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                  (SEE IDEOGRAM BELOW )
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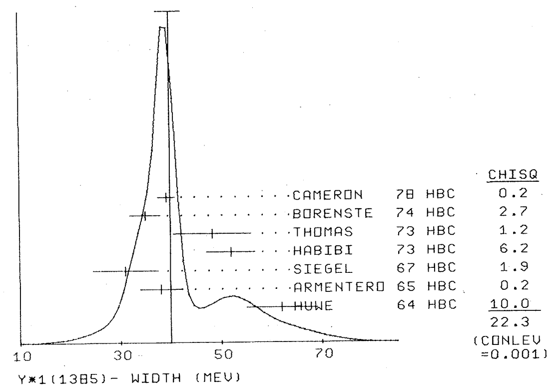
WEIGHTED AVERAGE = 39.9 ± 2.4
ERROR SCALED BY 1.9

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             43   Y*1(1385) REAL PART OF POLE POSITION                        4/75

RE+        1379.0      1.0              LICHTENB   74       +  EXTRAP HABIBI73   4/75
RE-        1383.0      1.0              LICHTENB   74       -  EXTRAP HABIBI73   4/75

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             43   Y*1(1385) IMAGINARY PART OF POLE POSITION                   4/75

IM+          17.5     1.5               LICHTENB   74       +  EXTRAP HABIBI73   4/75
IM-          22.5     1.5               LICHTENB   74       -  EXTRAP HABIBI73   4/75

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             43   Y*1(1385) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1       Y*1(1385) INTO LAMBDA PI                           1115+ 139
P2       Y*1(1385) INTO SIGMA PI                            1197+ 139
P3       Y*1(1385) INTO LAMBDA GAMMA                        1115+   0
P4       Y*1(1385) INTO KBAR N                               493+ 938
P5       Y*1(1385) INTO SIGMA GAMMA                         1197+   0

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             43   Y*1(1385) BRANCHING RATIOS

R1       Y*1(1385) INTO (SIGMA PI)/(LAMBDA PI)              (P2)/(P1)
R1             (0.04)    (0.04)         BASTIEN    61 HBC  +-
R1             (0.04) OR LESS           ALSTON     62 HBC  +-OK-P 1.15 BEV/C
R1              0.09      0.04          HUWE       64 HBC  +- K-P 1.2-1.7 GEV
R1              0.163     0.041         ARMENTERO  65 HBC  +- K-P .95-1.20 GEV   7/66
R1              0.08      0.06          LONDON     66 HBC  +  K-P 2.24 BEV/C      7/66
R1              0.13      0.04          PAN        69 HBC  +  PI+ P - K Y PI     12/72
R1              0.13      0.04          COLLEY     71 DBC  -0 K-N 1.5 GEV PROD 10/71
R1               .16       .07          AGUILAR    72 HBC  +  K-P 3.9,4.6 GEV   10/74
R1               .18       .04          MAST2      73 MPWA +- K-P - 2PI SIG/LM   9/73
R1               .10       .05          THOMAS     73 HBC  -  PI-P TO PI K Y      9/73
R1               .16       .03          BERTHON    74 HBC  +  K-P 1263-1843MEV 11/77
R1               .11       .02          BERTHON    74 HBC  -  K-P 1263-1843MEV 11/77
R1               .21       .05          BORENSTE   74 HBC  +  K-P TO(1385)+PIS 10/74
R1               .20       .06          DIONISI    78 HBC  +- K-P TO Y* K KBAR  3/79*
R1              . . . . . . . . .
R1   AVG        0.135     0.011   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1   STUDENT    0.135     0.013   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R2       Y*1(1385) INTO LAMBDA GAMMA                        (P3)
R2         1   (0.17)    (0.17)         MEISNER    72 HBC  0  1 EVENT ONLY       1/73

R3       Y*1(1385) FROM KBAR N TO LAMBDA PI                 SQRT(P1*P4)          4/75
R3 C           +.586      .319          DEVENISH   74         0 FIXED T DISP REL 4/75
R3 C      EXTRAPOLATION OF PARAMETRIZED AMPLITUDE BELOW THRESHOLD                4/75

R4       Y*1(1385) INTO (LAMBDA GAMMA)/(LAMBDA PI)          (P3)/(P1)            1/76
R4             (.06) OR LESS  CL=.90    COLAS      75 HLBC 0 K-P 575-970 MEV     1/76

R5       Y*1(1385) INTO (SIGMA GAMMA)/(LAMBDA PI)           (P5)/(P1)            1/76
R5             (.05) OR LESS  CL=.90    COLAS      75 HLBC 0 K-P 575-970 MEV     1/76

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Data Card Listings

For notation, see key at front of Listings.

Baryons

$\Sigma(1385)$, $\Sigma(1480)$, $\Sigma(1560)$, $\Sigma(1580)$

REFERENCES FOR Y*1(1385)

ALSTON 60 PRL 5 520 +ALVAREZ,EBERHARD,GOOD,GRAZIANO, + (LRL) I
BASTIEN 61 PRL 6 702 P BASTIEN,M FERRO-LUZZI,A H ROSENFELD (LRL)
BERGE 61 PRL 6 557 +BASTIEN,DAHL,FERRO-LUZZI,KIRZ, + (LRL)
DAHL 61 PRL 6 142 +HORWITZ,MILLER,MURRAY,WHITE (LRL)
ELY 61 PRL 7 461 +FUNG,GIDAL,PAN,POWELL,WHITE (LRL) J
MARTIN 61 PRL 6 283 +LEIPUNER,CHINOWSKY,SHIVELY, + (BNL,YALE)

ALSTON 62 CERN CONF 311 +ALVAREZ,FERRO-LUZZI,ROSENFELD, + (LRL)
COLLEY 62 PR 128 1930 +GELFAND,NAUENBERG, + (COLUMBIA,RUTGERS) JP
CURTIS 63 PR 132 1771 +COFFIN,MEYER,TERWILLIGER (MICH) J
COOPER 64 PL 8 365 +FILTHUTH,FRIDMAN,MALAMUD, + (CERN,AMST)
HUWE 64 UCRL-11291 THESIS D O HUWE (LRL) JP
ALSO 69 PR 180 1824 D O HUWE (LRL)

ARMENTER 65 PL 19 75 ARMENTEROS, + (CERN,HEIDEL,SACLAY)
BALTAY 65 PR 140 B1027 +SANDWEISS,TAFT,CULWICK,KOPP, + (YALE,BNL)
MUSGRAVE 65 NC 35 735 +PETMEZAS,+ (BIRM,CERN,EPOL,LOIC,SACLAY)
SMITH 65 THESIS (UCLA) L T SMITH (UCLA)

BIRMINGH 66 PR 152 1148 BIRMINGHAM,GLASGOW,I.C., OXFORD,RUTHERFORD
LONDON 66 PR 143 1034 +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+ (BNL,SYRA) J
SIEGEL 67 UCRL 18041 THESIS D M SIEGEL (LRL)
PAN 69 PRL 23 808 +FORMAN (PENN) I
AGUILAR 70 PRL 25 58 +BARNES, BASSANO, CHUNG, EISNER,+(BNL,SYRA)
ATHERTON 71 NP B29 477 +CELNIKIER,CLAYTON,FRENCH,FRISK,+ (CERN)
COLLEY 71 NP B31 61 +COX,EASTWOOD,FRY+.. (BIRM+EDIN+GLAS+LOIC)

AGUILAR 72 PR D6 29 AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS (BNL)
MEISNER 72 NC 12A 62 G MEISNER (U NC GREENSBORO+LBL)
AMMANN 73 PRD 7 1345 +CARMONY,GARFINKEL,GUTAY,+ (PURD+IUPU)
MAST2 73 PRD 7 3212 +BANGERTER,ALSTON-GARNJOST,+ (LBL)IJP
ALSO 73 PRD 7 5 MAST,BANGERTER,ALSTON-GARNJOST,+ (LBL)IJP
HABIBI 73 NEVIS 199(THESIS) M.HABIBI (COLUMBIA)
ALSO 73 PURD73, PG. 387 BALTAY,BRIDGEWATER,COOPER,+ (COLUMBIA+BING)
THOMAS 73 NP B56 15 THOMAS,ENGLER,FISK,KRAEMER (CARN) JP

BERTHON 74 NC 21A 146 BERTHON,TRISTRAM,+ (CDEF+RHEL+SACL+STRB)
BORENSTE 74 PR D9 3006 BORENSTEIN,KALBFLEISCH,STRAND,+ (BNL+MICH)
DEVENISH 74 NP B81 330 DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LCUC)
LICHTENB 74 PRD 10 3865 D B LICHTENBERG (INDIANA UNIVERSITY)
ALSO 74 PRIV. COMM. D B LICHTENBERG (INDIANA UNIVERSITY)

ATHERTO1 75 NC 25A 1 ATHERTON,BAR-NIR,FRENCH (CERN)
BARDADIN 75 NP B98 418 BARDADIN-OTWINOWSKA+ (SACL+EPOL+RHEL)
COLAS 75 NP B91 253 COLAS,FARWELL,FERRER,SIX (ORSA)

BARREIRO 77 NP B126 319 +BERGE,GANGULI,BLOKZIJL+ (CERN+AMST+NIJM)
HOLMGREN 77 NP B119 261 +AGUILAR-BENITEZ,KLUYVER+ (CERN+AMST+NIJM)
ALSTON 78 PR D18 182 ALSTON-GARNJOST,KENNEY+ (LBL+MHCO+CERN)
CAMERON 78 NP B143 189 +FRANEK,GOPAL,BACON,BUTTERWORTH+ (RHEL+LCIC)
DIONISI 78 PL 78B 154 +ARMENTEROS,DIAZ (CERN+AMST+NIJM+OXF)

BANERJEE 79 ZPHY C3 1 +GANGULI,MALHOTRA,RAGHAVAN,SUDHAKAR (TATA)
BAUBILLI 79 NP B148 18 BAUBILLIER+ (BIRM+CERN+GLAS+MSU+LPNP)
CAUTIS 79 NP B156 507 +BALLAM,BOUCHEZ,CARROLL,CHADWICK+ (SLAC)
SUGAHARA 79 NP B156 237 +OCHIAI,FUKUI,COOPER+ (KEK+OSKC+KINK)

PAPERS NOT REFERRED TO IN DATA CARDS

MALAMUD 64 PL 10 145 E MALAMUD, P E SCHLEIN (CERN,UCLA) JP
SHAFER 64 PR 134 B1372 J B SHAFER, D O HUWE (LRL) JP
HUNGERBU 74 PRD 10 2051 HUNGERBUHLER,MAJKA,+ (YALE,FNAL,BNL,PITT)

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Σ(1480) BUMPS

23 Y*1(1480, JP=) I=1 PRODUCTION EXPERIMENTS

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

PEAKS ARE SEEN IN LAMBDA PI AND SIGMA PI SPECTRA IN THE REACTION PI+P TO K+ PI Y AT 1.7 GEV/C. ALSO THE Y POLARIZATION OSCILLATES IN THE SAME REGION.

SEE MILLER 70 FOR A DISCUSSION OF THIS STATE. HE SUGGESTS A POSSIBLE ALTERNATE EXPLANATION IN TERMS OF A REFLECTION OF N*1/2(1670) DECAY TO LAMBDA K. HOWEVER, SUCH AN EXPLANATION FOR THE K+ SIGMA+ PIO CHANNEL SEEMS UNLIKELY (SEE PAN 70) IN TERMS OF KNOWN N*3/2(1690) DECAY INTO SIGMA K. IN ADDITION SUCH REFLECTIONS WOULD ALSO HAVE TO ACCOUNT FOR THE OSCILLATION OF THE Y POLARIZATION IN THE 1480 MASS REGION.

HANSON 71, WITH FEWER DATA THAN PAN 70, CAN NEITHER CONFIRM NOR DENY THE EXISTENCE OF THIS STATE. MAST 75 SEES NO STRUCTURE IN THIS MASS REGION IN K- P TO LAMBDA PIO.

23 Y*1(1480) MASS (MEV) (PROD. EXP.)

M	1479.	10.	PAN	70 HBC	+ PI+P TO K PI LAM	3/71
M	1465.	15.	PAN	70 HBC	+ PI+P TO K PI SIG	3/71
M	1485.	10.	CLINE	73 MPWA	K- D TO LM PI- P	9/73
M	. . . .					
M	AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)					

23 Y*1(1480) WIDTH (MEV) (PROD. EXP.)

W	31.	15.	PAN	70 HBC	+ PI+P TO K PI LAM	3/71
W	30.	20.	PAN	70 HBC	+ PI+P TO K PI SIG	3/71
W	40.	20.	CLINE	73 MPWA	K- D TO LM PI- P	9/73
W	. . . .					
W	AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)					

23 Y*1(1480) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	Y*1(1480) INTO KBAR N	497+ 939
P2	Y*1(1480) INTO LAMBDA PI	1115+ 139
P3	Y*1(1480) INTO SIGMA PI	1189+ 139

23 Y*1(1480) BRANCHING RATIOS (PROD. EXP.)

R1	Y*1(1480) INTO (SIGMA PI)/(LAMBDA PI)				(P3)/(P2)	
R1	0.82	0.51	PAN	70 HBC	+	3/71
R2	Y*1(1480) INTO (PROTON KOBAR)/(LAMBDA PI)				(P1)/(P2)	
R2	0.36	0.25	PAN	70 HBC	+	3/71
R3	Y*1(1480) INTO KBAR N				(P1)	9/73
R3	SMALL		CLINE	73 MPWA	K- D TO LM PI- P	9/73

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REFERENCES FOR Y*1(1480) (PROD. EXP.)

PAN 70 PR D2, 49 +FORMAN,KO,HAGOPIAN,SELOVE (PENN)
CLINE 73 LNC 6 205 CLINE,LAUMANN,MAPP (WISCONSIN)IJP

PAPERS NOT REFERRED TO IN DATA CARDS

YU-LI PA 69 PRL 23 806 YU-LI PAN, F L FORMAN (PENN) I
YU-LI PA 69 PRL 23 808 YU-LI PAN, F L FORMAN (PENN) I
MILLER 70 DUKE 229 D H MILLER (REVIEW TALK) (PURDUE)
HANSON 71 PR D4 1296 ,KALMUS,LOUIE (LBL) I
MAST 75 PRD 11 3078 +ALSTON-GARNJOST,BANGERTER+ (LBL)

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Σ(1560) BUMPS

80 Y*1(1560, JP=) I=1 PRODUCTION EXPERIMENTS

THIS ENTRY LISTS PEAKS REPORTED IN MASS SPECTRA AROUND 1560 MEV WITHOUT IMPLYING THAT THEY ARE NECESSARILY RELATED.
DIONISI 78 OBSERVE A 6 STD. DEV. ENHANCEMENT AT 1553 MEV IN THE CHARGED (LAMBDA/SIGMA PI) MASS SPECTRA FROM K-P --> LAMBDA/SIGMA PI K KBAR AT 4.2 GEV/C.
IN A CERN ISR EXPERIMENT, LOCKMAN 78 REPORT A NARROW 6 STD. DEV. ENHANCEMENT AT 1572 MEV IN THE LAMBDA PI+/PI- SYSTEMS FROM THE REACTION PP --> LAMBDA PI+ PI- + ANYTHING AT C.M. ENERGIES OF 53 AND 62 GEV.
THESE ENHANCEMENTS ARE UNLIKELY TO BE ASSOCIATED WITH THE Y*1(1580) (WHICH HAS NOT BEEN CONFIRMED BY SEVERAL RECENT EXPERIMENTS - SEE THE DATA CARD LISTINGS BELOW).
CARROLL 76 OBSERVE A BUMP AT 1550 MEV (AS WELL AS AT 1580 MEV) IN THE K-N I=1 TOTAL CROSS SECTION, BUT UNCERTAINTIES IN CROSS SECTION MEASUREMENTS OUTSIDE THE MASS RANGE OF THE EXPERIMENT PRECLUDE ESTIMATING ITS SIGNIFICANCE.
IN NEED OF CONFIRMATION. OMITTED FROM TABLES.

80 Y*1(1560) MASS (MEV) (PROD. EXP.)

M	121	1553.	7.	DIONISI	78 HBC	+- K-P TO Y* K KBAR	3/79*
M	40	1572.	4.	LOCKMAN	78 SPEC	+- PP TO L PI PI X	12/79*
M		. . . .					
M	AVERAGE MEANINGLESS (SCALE FACTOR = 2.4)						

80 Y*1(1560) WIDTH (MEV) (PROD. EXP.)

W		121	79.	30.	DIONISI	78 HBC	+- K-P TO Y* K KBAR	3/79*
W	C	40	15.	6.	LOCKMAN	78 SPEC	+- PP TO L PI PI X	12/79*
W	C	OBSERVED WIDTH CONSISTENT WITH EXPERIMENTAL RESOLUTION.						
W		. . . .						
W	AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)							

80 Y*1(1560) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	Y*1(1560) INTO LAMBDA PI	1115+ 139
P2	Y*1(1560) INTO SIGMA PI	1197+ 139

80 Y*1(1560) BRANCHING RATIOS (PROD. EXP.)

R1	Y*1(1560) INTO SIGMA PI/(SIGMA PI + LAMBDA PI)			(P2)/(P1+P2)		
R1	0.35	0.12	DIONISI	78 HBC	+- K-P TO Y* K KBAR	3/79*
R2	Y*1(1560) INTO LAMBDA PI			(P1)		
R2	SEEN		LOCKMAN	78 SPEC	+- PP TO L PI PI X	12/79*

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REFERENCES FOR Y*1(1560) (PROD. EXP.)

DIONISI 78 PL 78B 154 +ARMENTEROS,DIAZ+ (CERN+AMST+NIJM+OXF)I
LOCKMAN 78 CEN DPHPE 78-01 +MEYER,RANDER,POSTER,SCHLEIN+ (UCLA+SACL)

PAPERS NOT REFERRED TO IN DATA CARDS

CARROLL 76 PRL 37 806 +CHIANG,KYCIA,LI,MAZUR,MICHAEL+ (BNL)I

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Σ(1580)

00 Y*1(1580, JP=3/2-) I=1 D'_{13} 4/75

OBSERVED IN K- N I=1 TOTAL CS WITHOUT JP ASSIGNMENT AT BNL(LI 73, CARROLL 73, CARROLL 76) AND IN PWA OF K- P --> LAMBDA PI FOR CM ENERGIES=1560-1600 MEV BY LITCHFIELD 74. LITCHFIELD 74 FINDS JP=3/2-. NOT SEEN B ENGLER 78 OR BY CAMERON 78 (WITH LARGER STATISTICS), IN KLONG P TO PI+ LAMBDA AND PI+ SIGMA0.

00 Y*1(1580) MASS (MEV) 4/75

M	L	1582.	4.	LITCHFIEL	74 DPWA	0 K- P TO LAM PI	4/75
M	C	1583.	4.	CARROLL	76 DPWA	I=1 TOTAL CS	2/77

00 Y*1(1580) WIDTH (MEV) 4/75

W	L	11.	4.	LITCHFIEL	74 DPWA	0 K- P TO LAM PI	4/75
W	C	(15.)		CARROLL	76 DPWA	I=1 TOTAL CS	2/77

Baryons
Σ(1580), Σ(1620)


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                    00  Y*1(1580) PARTIAL DECAY MODES                          4/75

                                                               DECAY MASSES
P1     Y*1(1580) INTO KBAR N                                   497+ 939
P2     Y*1(1580) INTO LAMBDA PI                               1115+ 139
P3     Y*1(1580) INTO SIGMA PI                                1197+ 139

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                    00  Y*1(1580) BRANCHING RATIOS                             4/75

R1     Y*1(1580) INTO KBAR N/TOTAL                          (P1)               4/75
R1 L         +.03       .01       LITCHFIEL 74 DPWA    KBAR N MULTICHNL  4/75
R1 L    MAIN EFFECT OBSERVED BY LITCHFIELD 74 IS IN PI LAMBDA FINAL STATE,    4/75
R1 L    KBAR N AND SIGMA PI COUPLINGS ALSO ESTIMATED FROM MULTICHANNEL FIT    4/75
R1 L    INCLUDING TOTAL CROSS SECTION DATA (LI 73).                           4/75
R1    C TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.06   SEEN BY CARROLL 76       2/77

R2     Y*1(1580) FROM KBAR N TO LAMBDA PI                SQRT(P1*P2)           4/75
R2 L         +.10       .02       LITCHFIEL 74 DPWA  0 K- P TO LAM PI    4/75
R2         NOT SEEN               CAMERON   78 HBC  +  KL P TO PI+ LAM    1/78
R2         NOT SEEN               ENGLER    78  HBC +  KL P TO PI+ LAM    2/77

R3     Y*1(1580) FROM KBAR N TO SIGMA PI                 SQRT(P1*P3)           4/75
R3 L         +.03       .04       LITCHFIEL 74 DPWA    KBAR N MULTICHNL  4/75
R3         NOT SEEN               CAMERON   78 HBC  +  KL P TO PI+ SIGO   1/78
R3         NOT SEEN               ENGLER    78  HBC +  KL P TO PI+ SIGO   2/77

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                            REFERENCES FOR Y*1(1580)

LITCHFIE 74 PL 51B 509       LITCHFIELD                                 (CERN)IJP
CARROLL  76 PRL 37 806       +CHIANG,KYCIA,LI,MAZUR,MICHAEL+             (BNL)I
ENGLER   76 PL 63B 231       +KEYES,KRAEMER,SCHLERETH,TANAKA+ (CARN,ANL)I
CAMERON  78 NP B132 189      +CAPILUPPI+          (BGNA+EDIN+GLAS+PISA+RHEL)I
ENGLER   78 PR D18 3061      +KEYES,KRAEMER,TANAKA,CHO,+           (CARN,ANL)

                            PAPERS NOT REFERRED TO IN DATA CARDS

CARROLL  73 APS BRKLY MTG 208 CARROLL,CHIANG,KYCIA,LI,MAZUR,MICHAEL+(BNL)I
LI       73 PURDUE CONF. 283  LI                                          (BNL)I

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Note on Σ(1620)

This state was first suggested by the BNL-CCNY collaboration (CRENNELL 68) who presented evidence for it in the reaction $K^-n \to \Sigma(1620)^{\pm}\pi^{\mp}\pi^-$ with $\Sigma(1620)^{\pm}$ decaying into $\Lambda\pi^{\pm}$. Since then there have been conflicting reports about this state (or states).

Total Cross-Section Experiment

A measurement of the K^-p and K^-d total cross sections in the 0.4 to 1.1 GeV/c range has been reported by the BNL group (CARROLL 76). Three narrow (10 - 15 MeV wide) bumps in the $I = 1$ K^-N cross section are seen at 1583, 1608, and 1633 MeV.

Formation Experiments

There is evidence from several partial-wave analyses for one or two fairly narrow states within ~50 MeV of the effect seen in production; see the entries for $\Sigma(1580,3/2^-)$, $\Sigma(1620,1/2^-)$, and $\Sigma(1660, 1/2^+)$. Note however that the various analyses do not agree on the widths and branching ratios of these states.

Production Experiments

A good review of the production experiments has been given by MILLER 70. There has been no new evidence from production experiments since 1970. The existing evidence is only in the $\Lambda\pi$ channel. The BNL-CCNY collaboration (CRENNELL 69) claimed the effect in the $\Lambda\pi$ channel with no evidence seen in $\overline{K}N$ or $\overline{K}N\pi$. SABRE 70 studied the same reaction at 3.0 GeV/c with comparable statistics and did not see any evidence for it in the $\Lambda\pi$ channel; on the contrary, they believed it to be a spurious peak resulting from misidentified Σ^0 from the production of $\Sigma(1670)$ decaying into $\Sigma^0\pi^+$. AMMANN 70 studied the same reaction at 4.5 GeV/c and reported a state at 1640 MeV, again decaying only into $\Lambda\pi$ (no evidence seen in $\Sigma\pi$ or $\overline{K}N$ channels). Upper limits on production cross sections for a 25 GeV/c Σ^- beam are reported by HUNGERBUHLER 74.

In conclusion, for understanding of the Σ(1620) we probably have to wait for more data and for a more complete understanding of the entire mass region from 1600 to 1700 MeV. The closeness of the Σ(1620) mass to 1670 MeV is suggestive that this effect may be related to what goes on in that region (see the "Note on Σ(1670)" below).

Σ(1620) → **S'_{11}**

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32  Y*1(1620, JP=1/2-) I=1

THE S11 STATE AT 1697 MEV REPORTED BY VANHORN 75 IS
INTERMEDIATE IN MASS BETWEEN THE SIGMA(1620) AND
SIGMA(1750).  WE TENTATIVELY LIST IT UNDER SIGMA(1750).
CARROLL 76 SEES TWO BUMPS IN THE I=1 TOTAL CROSS
SECTIONS NEAR THIS MASS.

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                    32  Y*1(1620) MASS (MEV)

M           (1620.)                      KIM       71 DPWA    K-MATRIX ANAL.    3/71
M            1630.0    (10.0)            LANGBEIN  72 IPWA    MULTICHANNEL     12/72
M     L      16C8.       5.              CARROLL   76 DPWA    I=1 TOTAL CS      2/77
M      H     1633.      10.              CARROLL   76 DPWA    I=1 TOTAL CS      2/77
M   1       (1600.0)    (6.0)            MORRIS    78 DPWA -  K- N TO LAM PI-   3/79*
M   1   AN EQUALLY GOOD FIT IS OBTAINED WITHOUT INCLUDING THIS RESONANCE.     3/79*
M           . . . . . . . . . . .
M   AVG      1613.0     10.0       AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
M   STUDENT1612.1        5.6       AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    32  Y*1(1620) WIDTH (MEV)

W            -(40.)                      KIM       71 DPWA    K-MATRIX ANAL.    3/71
W             65.0     (20.0)            LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W     L      (15.)                       CARROLL   76 DPWA    I=1 TOTAL CS      2/77
W      H     (10.)                       CARROLL   76 DPWA    I=1 TOTAL CS      2/77
W   1        (87.0)    (19.0)            MORRIS    78 DPWA -  K- N TO LAM PI-   3/79*

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                    32  Y*1(1620) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     Y*1(1620) INTO KBAR N                              497+ 939
P2     Y*1(1620) INTO SIGMA PI                           1197+ 139
P3     Y*1(1620) INTO LAMBDA PI                          1115+ 134

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                    32  Y*1(1620) BRANCHING RATIOS

R1     Y*1(1620) INTO KBAR N                                 (P1)
R1         (0.05)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1 A        0.05  OR LESS             WONG      71 DPWA    K-+P--LAM+PI     10/71
R1          0.22     (0.02)           LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1    L TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.06   SEEN BY CARROLL 76      2/77
R1    H TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.04   SEEN BY CARROLL 76      2/77
R1 A    K-MATRIX FIT(NEGLECTS 3-BODY CHANNELS) REQUIRES NO RESONANCE         10/71

R2     Y*1(1620) FROM KBAR N TO SIGMA PI                  SQRT(P1*P2)
R2         (0.08)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2          0.40     (0.06)           LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R2        NOT SEEN                    HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77

R3     Y*1(1620) FROM KBAR N TO LAMBDA PI                 SQRT(P1*P3)
R3         (0.15)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
R3        NOT SEEN                    BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R3  1      (0.12)    (0.02)           MORRIS    78 DPWA -  K- N TO LAM PI-   3/79*

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Data Card Listings

For notation, see key at front of Listings.

Baryons
Σ(1620), Σ(1660)


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                              REFERENCES FOR Y*1(1620)

KIM       71 PRL 27 356       J K KIM                                  (HARV)IJP
  ALSO 70 DUKE 161            J. K. KIM                                (HARV)IJP
WONG      71 NC 2A 353        N S WONG                                 (YALE)IJP
LANGBEIN 72 NP B47 477        +WAGNER                                  (MPIM)IJP

BAILLON   75 NP B94 39        P. BAILLON,P. J. LITCHFIELD      (CERN,RHEL)IJP
CARROLL   76 PRL 37 806       +CHIANG,KYCIA,LI,MAZUR,MICHAEL+          (BNL)I
HEPP2     76 PL 65B 487       +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)IJP
MORRIS    78 PR D17 55        +ALBRIGHT,COLLERAINE,KIMEL,LANNUTTI      (FSU)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS

VANHORN   75 NP B87 145       A. J. VAN HORN                           (LBL)IJP
  ALSO 75 NP B87 157          A. J. VAN HORN                           (LBL)IJP
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1620 MEV REGION — PRODUCTION EXPERIMENTS

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          78  Y*1(1620, JP=      ) I=1          PRODUCTION EXPERIMENTS

          SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

          THIS RESONANCE NEEDS CONFIRMATION. THE RESULTS OF
          CRENNELL 69 AT 3.9 GEV/C ARE NOT CONFIRMED BY THE SABRE
  COLLABORATION AT 3.0 GEV/C (SABRE 70).  HOWEVER IN AN EXPERIMENT AT
  4.5 GEV/C, AMMANN 70 SEE A PEAK AT 1642 MEV WHICH ON THE BASIS OF
  BRANCHING RATIOS THEY DO NOT ASSOCIATE WITH THE Y*1(1670). SEE MILLER
  70 FOR A REVIEW OF THESE CONFLICTS.

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          78  Y*1(1620) MASS (MEV) (PROD. EXP.)

M   N      (1616.0)    (8.0)        CRENNELL   68 DBC  +- K-D 3.9 BEV/C    11/68
M   N     EVENTS OF CRENNELL 68 ARE IN THE LARGER SAMPLE OF CRENNELL 69.
M       20 1618.0      3.0          BLUMENFEL 69 HBC  +  K0 LONG + PROTON  9/69
M          1619.0      8.0          CRENNELL   69 DBC  +- K-N TO LAM 3 PI  9/69
M          1642.0     12.0          AMMANN     70 DBC     K-N 4.5 GEV/C    9/73
M          . . . . . . . . .
M   AVG     1619.4     3.8    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
M   STUDENT1619.1      3.0    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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          78  Y*1(1620) WIDTH (MEV) (PROD. EXP.)

W   N      (66.0)     (16.0)        CRENNELL   68 DBC  +- SEE NOTE N ABOVE 11/68
W       20  30.0       10.0         BLUMENFEL 69 HBC  +                    9/69
W           72.0       22.0   15.0  CRENNELL   69 DBC  +-                  9/69
W           55.0       24.0         AMMANN     70 DBC     K-N 4.5 GEV/C    9/73
W          . . . . . . . . .
W   AVG     41.3       12.2   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
W   STUDENT 40.7       10.4   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
          SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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          78  Y*1(1620) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1     Y*1(1620) INTO KBAR N                             497+ 939
P2     Y*1(1620) INTO LAMBDA PI                          1115+ 139
P3     Y*1(1620) INTO Y*1(1385) PI                       1384+ 139
P4     Y*1(1620) INTO LAMBDA PI PI                       1115+ 139+ 139
P5     Y*1(1620) INTO SIGMA PI                           1197+ 139
P6     Y*1(1620) INTO Y*0(1405) PI                       1405+ 139

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          78  Y*1(1620) BRANCHING RATIOS (PROD. EXP.)

R1     Y*1(1620) INTO (LAMBDA PI PI)/(LAMBDA PI)          (P4)/(P3)
R1      14   (2.5)  APPROX             BLUMENFEL 69 HBC  +

R2     Y*1(1620) INTO (KBAR N)/(LAMBDA PI)                (P1)/(P2)
R2         (0.0)     (0.1)             CRENNELL   68 DBC  +
R2          0.4       0.4              AMMANN     70 DBC     K-P 4.5 GEV/C     6/70

R3     Y*1(1620) INTO LAMBDA PI                           (P2)
R3          LARGE                      CRENNELL   68 DBC  +-                  11/68

R4     Y*1(1620) INTO (Y*1(1385) PI)/(LAMBDA PI)          (P3)/(P2)
R4         (0.2)     (0.1)             CRENNELL   68 DBC  +-                  11/68
R4         (0.3)  OR LESS  CL=.95      AMMANN     70 DBC     K-P 4.5 GEV/C     6/70

R5     Y*1(1620) INTO (SIGMA PI)/(LAMBDA PI)              (P5)/(P2)
R5          (1.1)(95 PC UPPER LIMIT) AMMANN      70 DBC     K-N 4.5 GEV/C     9/73

R6     Y*1(1620) INTO (Y*0(1405) PI)/(LAMBDA PI)          (P6)/(P2)
R6          0.7       0.4              AMMANN     70 DBC     K-P 4.5 GEV/C     6/70

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                              REFERENCES FOR Y*1(1620) (PROD. EXP.)

CRENNELL 68 PRL 21 648        +DELANEY, FLAMINIO, KARSHON, +    (BNL,CUNY) I
BLUMENFE 69 PL 29B 58         BLUMENFELD, KALBFLEISCH                 (BNL) I
CRENNELL 69 LUND PAPER 183    +KARSHON, LAI, ONEIL, SCARR, +    (BNL,CUNY) I
   RESULTS ARE QUOTED IN LEVI SETTI 69.

AMMANN    70 PRL 24 327       + GARFINKEL, CARMONY, GUTAY,+     (PURDUE, IND)
   ALSO 73 PR D7 1345         AMMANN,CARMONY,GARFINKEL,           (PURD+IUPU)

                              PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 68 NP B8 183         ARMENTEROS,BAILLON +          (CERN+HEID+SACL)
LEVISETT 69 LUND CONF         R LEVI SETTI     (RAPPORTEUR)           EFINS
TRIPP     69 UCRL 19361       R D TRIPP                              (LRL)
ARMENTER 70 DUKE 123          ARMENTEROS,BAILLON +          (CERN+HEID+SACL)
MILLER    70 DUKE 229         D H MILLER   (REVIEW TALK)            (PURDUE)
SABRE     70 NP B16 201       SABRE COLLAB.     (SACL,AMST,BGNA,REHO,EPOL)
HUNGERBU 74 PR D10 2051       HUNGERBUHLER,MAJKA,+     (YALE,FNAL,BNL,PITT)
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Σ(1660) P'_{11}

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          79  Y*1(1660, JP=1/2+) I=1

          SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

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          79  Y*1(1660) MASS (MEV)

M         1500. -- 1600.              ARMENTERO 70 HDBC -0 K-N TO SIGMA PI    6/70
M         (1670.)                     KIM        71 DPWA    K-MATRIX ANAL.    3/71
M     2   (1621.)                     LEA        73 DPWA    MULTICHNL K-MTRX  9/73
M     2  ONLY UNCONSTRAINED STATES FROM TABLE 1 OF LEA73 ARE IN LISTINGS.     9/73
M          1658.        (4.)          HART       73 DPWA    EL+CX,.7-.8GEV/C  2/74
M     1   (1660.)      (30.)          BAILLON    75 IPWA    KBAR N TO LAM PI 11/75
M     1  FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2           11/75
M     3   (1671.)       (2.)          PONTE      75 DPWA  0 K- P TO LAM PI    1/76
M     3  FROM SOLUTION 2 OF PONTE 75, NOT PRESENT IN SOLUTION 1.              1/76
M          1668.       (25.)          VANHORN    75 DPWA  0 K- P TO LAM PI0  11/75
M     4    1565. OR 1597.             MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
M     4  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     4  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1676.       (15.)          RLIC       77 DPWA    KBAR N MULTICHNL  1/76
M          1679.       (10.)          ALSTON     78 DPWA    KBAR N ELASTIC    1/78

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          79  Y*1(1660) WIDTH (MEV)

W          (50.0)                     ARMENTERO 70 HDBC -0 K-N TO SIGMA PI    6/70
W          (50.)                      KIM        71 DPWA    K-MATRIX ANAL.    3/71
W     2    (51.8)                     LEA        73 DPWA    MULTICHNL K-MTRX  9/73
W           40.        (10.)          HART       73 DPWA    EL+CX,.7-.8GEV/C  2/74
W     1    (80.)       (40.)          BAILLON    75 IPWA    KBAR N TO LAM PI 11/75
W     3    (81.)       (10.)          PONTE      75 DPWA  0 K- P TO LAM PI    1/76
W          230.       (165.)   (60.)  VANHORN    75 DPWA  0 K- P TO LAM PI0  11/75
W     4    202. OR 217.               MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
W          120.        (20.)          RLIC       77 DPWA    KBAR N MULTICHNL  1/76
W           38.        (10.)          ALSTON     78 DPWA    KBAR N ELASTIC    1/78

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          79  Y*1(1660) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     Y*1(1660) INTO KBAR N                             497+ 939
P2     Y*1(1660) INTO SIGMA PI                           1197+ 139
P3     Y*1(1660) INTO LAMBDA PI                          1115+ 139

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          79  Y*1(1660) BRANCHING RATIOS

R1     Y*1(1660) FROM KBAR N TO SIGMA PI                 SQRT(P1*P2)
R1          (+0.2)                    ARMENTERO 70 HDBC -0 K-N TO SIGMA PI    6/70
R1          (0.24)                    KIM        71 DPWA    K-MATRIX ANAL.    3/71
R1    2     (-.21)                    LEA        73 DPWA    MULTICHNL K-MTRX  9/73
R1        NOT SEEN                    HEPP2      76 DPWA -0 K- NUC TO SIG PI  2/77
R1    4     (-.34)OR -.37             MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
R1          -.16      (.03)           RLIC       77 DPWA    KBAR N MULTICHNL  1/76

R2     Y*1(1660) INTO KBAR N                               (P1)
R2          (0.14)                    KIM        71 DPWA    K-MATRIX ANAL.    3/71
R2    2     (.10)                     LEA        73 DPWA    MULTICHNL K-MTRX  9/73
R2           .11      (.02)           HART       73 DPWA    EL+CX,.7-.8GEV/C  2/74
R2    4     (.27)OR .29               MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
R2          LESS THAN .04             RLIC       77 DPWA    KBAR N MULTICHNL  1/76
R2           .10      (.05)           ALSTON     78 DPWA    KBAR N ELASTIC    1/78

R3     Y*1(1660) FROM KBAR N TO LAMBDA PI                SQRT(P1*P3)
R3          (0.0)                     KIM        71 DPWA    K-MATRIX ANAL.    2/73
R3    2     (+.07)                    LEA        73 DPWA    MULTICHNL K-MTRX  9/73
R3    1     (-.04)    (.02)           BAILLON    75 IPWA    KBAR N TO LAM PI 11/75
R3    3     (+.16)    (.01)           PONTE      75 DPWA  0 K- P TO LAM PI    1/76
R3           .12      (.12)   (.04)   VANHORN    75 DPWA  0 K- P TO LAM PI0  11/75
R3    4     (-.10)OR -.11             MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
R3          LESS THAN .04             RLIC       77 DPWA    KBAR N MULTICHNL  1/76

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                              REFERENCES FOR Y*1(1660)

ARMENTER 70 DUKE 123          ARMENTEROS, BAILLON, +        (CERN,HEIDEL)IJP
KIM       71 PRL 27 356       J K KIM                                 (HARV)IJP
   ALSO 70 DUKE 161           J. K. KIM                               (HARV)IJP
HART      73 PURDUE CONF. 311 +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
LEA       73 NP B56 77        +MARTIN,MOORHOUSE+  (RHEL+LOUC+GLAS+AARHUS)IJP

BAILLON   75 NP B94 39        P. BAILLON,P. J. LITCHFIELD      (CERN,RHEL)IJP
PONTE     75 PRD 12 2597      +HERTZBACH,BUTTON-SHAFER+   (MASA+TENN+UCR)IJP
VANHORN   75 NP B87 145       A. J. VAN HORN                          (LBL)IJP
   ALSO 75 NP B87 157         A. J. VAN HORN                          (LBL)IJP

HEPP2     76 PL 65B 487       +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)IJP
MARTIN    77 NP B127 349      MARTIN,PIDCOCK,MOORHOUSE          (LOUC+GLAS)IJP
   ALSO 77 NP B126 266        MARTIN,PIDCOCK                          (LOUC)
   ALSO 77 NP B126 285        MARTIN,PIDCOCK                          (LOUC)IJP
RLIC      77 NP B119 362      GOPAL,ROSS,VAN HORN,MCPHERSON+   (LOIC+RHEL)IJP
ALSTON    78 PR D18 182       +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
   ALSO 77 PRL 38 1007        ALSTON-GARNJOST,KENNEY       (LBL+MTHO+CERN)IJP
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Baryons
Σ(1670)

Note on Σ(1670)

Production Experiments

The measured $\Sigma\pi/\Sigma\pi\pi$ branching ratio for produced Σ(1670)'s is strongly dependent on momentum transfer. This was first discovered by EBERHARD 69, who suggested the existence of two Y_1^*'s with the same mass and quantum numbers; one object with a large $\Sigma\pi\pi$ [mainly $\Lambda(1405)\pi$] decay mode produced peripherally, and another one with a large $\Sigma\pi$ decay mode produced at larger angles. This observation has been confirmed by AGUILAR-BENITEZ 70, ASPELL 74, ESTES 74, and TIMMERMANS 76. When determined, the most likely quantum numbers are $3/2^-$ [for both $\Sigma\pi$ and $\Lambda(1405)\pi$]. There is also the possibility of a third Y_1^* state, referred to as Σ(1690) in the Data Card Listings, with a large $\Lambda\pi/\Sigma\pi$ branching ratio and somewhat larger mass. The large branching ratio is the main justification for this hypothesis and needs confirmation. These problems have been reviewed by EBERHARD 73 and MILLER 70.

Formation Experiments

Two states are also observed near this mass in formation. One of these, the $\Sigma(1670, 3/2^-)$, has the same quantum numbers as those observed in production and a large $\Sigma\pi/\Sigma\pi\pi$ branching ratio. It may well correspond to the produced Σ(1670) seen at larger angles. (See TIMMERMANS 76 on this point.) The other state, the $\Sigma(1660, 1/2^+)$, has different quantum numbers from those seen in production, and its $\Sigma\pi/\Sigma\pi\pi$ branching ratio is unknown. Thus its relation to the produced Σ(1670) remains obscure. (See also the "Note on Σ(1620)" above.)

Σ(1670) 44 Y*1(1670, JP=3/2-) I=1 **D''_{13}**

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SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

WELL ESTABLISHED RESONANCE.  IT HAS BEEN SEEN IN BOTH
FORMATION AND PRODUCTION EXPERIMENTS.

SEE LISTING OF PRODUCTION EXPERIMENTS BELOW

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                 44  Y*1(1670) MASS (MEV)

M         1660.0                     BERLEY    64 HBC    0 K-P TO LAM PIO     7/66
M         1668.      (5.)            ARMENTER  68 HBC    0 K-P ELAS.+CH.EX   11/68
M        (1661.0)    (2.0)           ARMENTE2  68 HBC    0 K-P TO SIGMA PI   11/68
M         1680.                      ARMENTE4  69 DBC      K-N TO SIG- PIO   12/68
M         1663.0     (2.0)           ARMENT-5  69 HBC    0 K-P TO SIGMPI ED   9/69
M         1672.0                     BERLEY    69 HBC      K-P TO SIG PI      5/70
M         1660.                      ARMENTER  70 HBC    0 K-P TO LAM.PI EI   5/70
M         1681.0     (3.0)           BRUCKER   70 DBC  -   K-N TO SIG 2PI    10/71
M         1662.0     (5.0)           GALTIERI  70 HBC    0 SIG PI,EDPWA       7/70
M         1665.     (10.)            GALTIERI  70 HBC    0 LAM. PI, EDPWA     7/70
M         1676.      (2.)            BUDGEN    71 DPWA     LAM PIO,CHS DATA 10/71
M         1670.                      KIM       71 DPWA     K-MATRIX ANAL.     3/71
M         1675.0    (15.0)           LANGBEIN  72 IPWA     MULTICHANNEL      12/72
M         1685.     (20.)            BAILLON   75 IPWA     KBAR N TO LAM PI 11/75
M    C   (1671.)     (3.)            PONTE     75 DPWA   0 K- P TO LAM PI     1/76
M    C  FROM SOLUTICN 1 OF PONTE 75.                                          1/76
M    D   (1655.)     (2.)            PONTE     75 DPWA   0 K- P TO LAM PI     1/76
M    D  FROM SOLUTICN 2 OF PONTE 75.                                          1/76
M         1659.     (12.)     (5.)   VANHORN   75 DPWA   0 K- P TO LAM PIO   11/75
M        (1650.)                     BELLEFON  76 IPWA   0 K- P TO LAM PI     2/77
M         1670.      (6.)            HEPP2     76 DPWA -0 K- NUC TO SIG PI    2/77
M    1    1667. OR 1668.             MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
M    1  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESCNANCE
M    1  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M         1670.      (5.)            RLIC      77 DPWA     KBAR N MULTICHNL  1/76
M         1679.     (10.)            ALSTON    78 DPWA     KBAR N ELASTIC    1/78

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                 44  Y*1(1670) WIDTH (MEV)

W           60.0                     BERLEY    64 HBC    0                    7/66
W           56.     (18.)            ARMENTER  68 HBC    0 K-P ELAS.+CH.EX   11/68
W          (44.0)    (4.0)           ARMENTE2  68 HBC    0 K-P TO SIGMA PI   11/68
W           47.0                     ARMENTE4  69 DBC      K-N TO SIG- PIO   12/68
W           49.0     (4.0)           ARMENT-5  69 HBC    0 K-P TO SIGMPI ED   9/69
W           34.0                     BERLEY    69 HBC                         5/70
W           50.                      ARMENTER  70 HBC    0 K-P TO LAMB.PI     5/70
W           30.0    (10.0)           BRUCKER   70 DBC  -   K-N TO SIG 2PI    10/71
W           48.0     (5.0)           GALTIERI  70 HBC    0 SIG PI,EDPWA       7/70
W           50.     (10.)            GALTIERI  70 HBC    0 LAM. PI, EDPWA     7/70
W           59.      (4.5)           BUDGEN    71 DPWA     LAM PIO           10/71
W           40.                      KIM       71 DPWA     K-MATRIX ANAL.     3/71
W           65.0    (20.0)           LANGBEIN  72 IPWA     MULTICHANNEL      12/72
W           70.     (20.)            BAXTER    73 DPWA   0 K- P TO NEUTRALS 10/74
W           85.     (25.)            BAILLON   75 IPWA     KBAR N TO LAM PI 11/75
W    C     (44.)    (11.)            PONTE     75 DPWA   0 K- P TO LAM PI     1/76
W    D     (76.)     (5.)            PONTE     75 DPWA   0 K- P TO LAM PI     1/76
W           32.     (11.)            VANHORN   75 DPWA   0 K- P TO LAM PIO   11/75
W          (80.)                     BELLEFON  76 IPWA   0 K- P TO LAM PI     2/77
W           56.      (3.)            HEPP2     76 DPWA -0 K- NUC TO SIG PI    2/77
W    1      46. OR 46.               MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
W           50.      (5.)            RLIC      77 DPWA     KBAR N MULTICHNL  1/76
W           56.     (20.)            ALSTON    78 DPWA     KBAR N ELASTIC     1/78

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                 44  Y*1(1670) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1      Y*1(1670) INTO KBAR N                          497+ 939
P2      Y*1(1670) INTO LAMBDA PI                      1115+ 139
P3      Y*1(1670) INTO SIGMA PI                       1197+ 139
P4      Y*1(1670) INTO LAMBDA PI PI                   1115+ 139+ 139
P5      Y*1(1670) INTO SIGMA PI PI                    1197+ 139+ 139
P6      Y*1(1670) INTO Y*1(1385) PI S-WAVE             139+1384
P7      Y*1(1670) INTO Y*0(1405) PI                   1405+ 139
P8      Y*1(1670) INTO LAMBDA(1520) PI                 139+1518

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                 44  Y*1(1670) BRANCHING RATIOS

R1      Y*1(1670) INTO (KBAR N)/TOTAL                         (P1)
R1          (0.09)    (0.02)         ARMENTER  68 HBC                         9/69
R1           0.08     (0.02)         ARMENT-5  69 HBC    0 ELAS. +CH.EX. ED   9/69
R1           0.07                    KIM       71 DPWA     K-MATRIX ANAL.     3/71
R1           0.10     (0.03)         LANGBEIN  72 IPWA     MULTICHANNEL      12/72
R1           NOT SEEN                HART      73 DPWA     EL+CX,.7-.8GEV/C   2/74
R1   1      (.07)OR .07              MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
R1            .08      (.03)         RLIC      77 DPWA     KBAR N MULTICHNL  1/76
R1            .11      (.03)         ALSTON    78 DPWA     KBAR N ELASTIC     1/78

R2      Y*1(1670) INTO (LAMBDA PI PI)/TOTAL                   (P4)
R2          (0.11) OR LESS           ARMENTE3  68 HBC      K-P (P1=.09)       9/69

R3      Y*1(1670) INTO (SIGMA PI PI)/TOTAL                    (P5)
R3   A      (0.14) OR LESS           ARMENTE3  68 HBC      K-P AND D-P1=.09 11/68
R3   A   RATIO ONLY FOR (SIG2PI) SYSTEM IN I=1, WHICH CANNOT BE Y*1(1385)     11/68

R4      Y*1(1670) INTO (Y*0(1405) PI)/TOTAL                   (P7)
R4          (0.06) OR LESS           ARMENTE3  68 HBC      K-P AND D-P1=.09 11/68

R5      Y*1(1670) FROM KBAR N TO LAMBDA PI                    SQRT(P1*P2)
R5   2      (+0.1)                   ARMENTER  70HBC       K-P TO LAMB PI     5/70
R5   2  PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT) 10/74
R5          +0.09     (0.02)         GALTIERI  70 HBC    0 LAM. PI, EDPWA     7/70
R5            .165     (.01)         BUDGEN    71 DPWA     LAM PIO           10/71
R5           0.08                    KIM       71 DPWA     K-MATRIX ANAL.     3/71
R5           0.13     (0.03)         LANGBEIN  72 IPWA     MULTICHANNEL      12/72
R5           +.10      (.02)         BAXTER    73 DPWA   0 K- P TO NEUTRALS 10/74
R5           +.018      .060         DEVENISH  74        0 FIXED T DISP REL   4/75
R5           +.06      (.02)         BAILLON   75 IPWA     KBAR N TO LAM PI 11/75
R5   C      (.08)      (.01)         PONTE     75 DPWA   0 K- P TO LAM PI     1/76
R5   D      (.17)      (.01)         PONTE     75 DPWA   0 K- P TO LAM PI     1/76
R5           +.09      (.02)         VANHORN   75 DPWA   0 K- P TO LAM PIO   11/75
R5          (+.05)                   BELLEFON  76 IPWA   0 K- P TO LAM PI     2/77
R5   1      (+.08)OR +.08            MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
R5           +.10      (.02)         RLIC      77 DPWA     KBAR N MULTICHNL  1/76
R5   F       0.17     (0.03)         MORRIS    78 DPWA -   K- N TO LAM PI-   3/79*
R5   F       0.13     (0.02)         MORRIS    78 DPWA -   K- N TO LAM PI-   3/79*
R5   F   RESULTS ARE WITH AND WITHOUT AN S11 SIG(1620) IN THE FIT.

R6      Y*1(1670) FROM KBAR N TO SIGMA PI                     SQRT(P1*P3)
R6          (+0.21)   (0.01)         ARMENTE2  68 HBC    0 OLD DATA          11/68
R6          +0.19                    ARMENTE4  69 DBC                         9/69
R6          +0.20     (0.01)         ARMENT-5  69 HBC    0 NEW DATA           9/69
R6          +0.18                    BERLEY    69 HBC                         5/70
R6          +0.18     (0.06)         GALTIERI  70 HBC    0 SIG PI,EDPWA       7/70
R6           0.15                    KIM       71 DPWA     K-MATRIX ANAL.     3/71
R6           0.23     (0.05)         LANGBEIN  72 IPWA     MULTICHANNEL      12/72
R6           +.20      (.01)         HEPP2     76 DPWA -0 K- NUC TO SIG PI    2/77
R6   1      (+.18)OR +.17            MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
R6           +.21      (.02)         RLIC      77 DPWA     KBAR N MULTICHNL  1/76

R7      Y*1(1670) FROM KBAR N TO Y*1(1385) PI S-WAVE          SQRT(P1*P6)
R7   S      (0.17)    (0.02)         SIMS      68 DBC  -   LAM 2PI CROS.SEC 10/71
R7   S   SIMS 68 USES ONLY CROSS-SECT. DATA. RESULT USED AS UPPER LIMIT ONLY  3/72
R7           +.11       .03          PREVOST   74 DPWA 0-  K-N TO S(1385)PI 10/74

R8      Y*1(1670) INTO (Y*0(1405)PI)*(KBAR N)/TOTAL**2        (P7*P1)
R8          (0.03) OR LESS           BERLEY    69 HBC    0 K-P .6-.82 BEV/C   5/70
R8   B       0.007    (0.002)        BRUCKER   70 DBC  -   K-N TO SIG 2PI    10/71
R8   B   ASSUMING Y*0(1405) PI CROSS SECTION BUMP DUE SOLEY TO 3/2- RESON.   10/71

R9      Y*1(1670) INTO (Y*0(1405) PI)/(Y*1(1385) PI)          (P7)/(P6)
R9           0.23     (0.08)         BRUCKER   70 DBC  -   K-N TO SIG 2PI    10/71

R10     Y*1(1670) FROM KBAR N TO LAMBDA(1520) PI              SQRT(P1*P8)
R10  3        .081      .016         CAMERON   77 DPWA   0 P-WAVE DECAY       1/78
R10  3   CAMERON77 UPPER LIMIT ON F-WAVE DECAY IS .03                         1/78
R10  3   ASSUMES LAMBDA(1520) ELASTICITY=.46.                                 1/78

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Data Card Listings
For notation, see key at front of Listings.

Baryons
Σ(1670)

REFERENCES FOR Y*1(1670)

BERLEY 64 DUBNA CONF I 565 +CONNOLLY,HART,RAHM,STONEHILL, + (BNL)IJP

ARMENTER 68 NP B8 195 ARMENTEROS,BAILLON + (CERN+HEID+SACLAY)IJP
ARMENTE1 68 NP B8 183 ARMENTEROS,BAILLON + (CERN+HEID+SACLAY)IJP
ARMENTE2 68 NP B8 223 ARMENTEROS+BAILLON + (CERN+HEID+SACLAY)IJP
ARMENTE3 68 PL 28B 521 ARMENTEROS,BAILLON + (CERN+HEID+SACLAY)I
SIMS 68 PRL 21 1413 SIMS,ALBRIGHT,BARTLEY,MEER+ (FSU,TUFT,BRAN)

ARMENTE4 69 NP B10 459 ARMENTEROS,BAILLON,MINTEN + (CERN+SACLAY) J
ARMENT-5 69 NP B14 91 ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BERLEY 69 PL 30B 430 BERLEY,HART,RAHM,WILLIS,YAMAMOTO (BNL)

ARMENTER 70 DUKE 123 ARMENTEROS, BAILLON, + (CERN,HEID)
BRUCKER 70 DUKE 155 +HARRISON,SIMS,ALBRIGHT,CHANDLER++ (FSU)I
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)IJP
BUDGEN 71 LNC 2 85 D BUDGEN (DURH)IJP
KIM 71 PRL 27 356 J K KIM (HARV)IJP
ALSO 70 DUKE 161 J. K. KIM (HARV)IJP

LANGBEIN 72 NP B47 477 +WAGNER (MPIM)IJP
BAXTER 73 NP B67 125 BAXTER,BUCKINGHAM,CORBETT,DUNN,+ (OXFORD)IJP
HART 73 PURDUE CONF. 311 +RICE,BACASTOW,FUNG,+ (TENN+UCR+MASA+BUFF)IJP
DEVENISH 74 NP B81 330 DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
PREVOST 74 NP B69 246 PREVOST,BARLOUTAUD,+ (SACL+CERN+HEID)

BAILLON 75 NP B94 39 P. BAILLON,P. J. LITCHFIELD (CERN,RHEL)IJP
PONTE 75 PRD 12 2597 +HERTZBACH,BUTTON-SHAFER+ (MASA+TENN+UCR)IJP
VANHORN 75 NP B87 145 A. J. VAN HORN (LBL)IJP
ALSO 75 NP B87 157 A. J. VAN HORN (LBL)IJP

BELLEFON 76 NP B109 129 DE BELLEFON,BERTHON (CDEF)IJP
HEPP2 76 PL 65B 487 +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)IJP
CAMERON 77 NP B131 399 +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN 77 NP B127 349 MARTIN,PIDCOCK,MOORHOUSE (LOUC+GLAS)IJP
ALSO 77 NP B126 266 MARTIN,PIDCOCK (LOUC)
ALSO 77 NP B126 285 MARTIN,PIDCOCK (LOUC)IJP
RLIC 77 NP B119 362 GOPAL,ROSS,VAN HORN,MCPHERSON+ (LOIC+RHEL)IJP

ALSTON 78 PR D18 182 +KENNEY,POLLARD,ROSS+ (LBL+MTHO+CERN)IJP
ALSO 77 PRL 38 1007 ALSTON-GARNJOST,KENNEY (LBL+MTHO+CERN)IJP
MORRIS 78 PR D17 55 +ALBRIGHT,COLLERAINE,KIMEL,LANNUTTI (FSU)IJP

PAPERS NOT REFERRED TO IN DATA CARDS

BASTIEN1 63 PRL 10 188 P L BASTIEN, J P BERGE (LRL) IJ
REPLACED BY BASTIEN 2, BUT SIMILAR AND MORE READILY AVAILABLE.
BASTIEN2 63 UCRL-10779 THESIS P L BASTIEN (LRL) IJ
T-ZADEH 63 PRL 11 470 TAHER-ZADEH,PROWSE,SCHLEIN,SLATER,+ (UCLA) JP
SEE NOTE FOLLOWING SCHLEIN 66.
SCHLEIN 66 UCLA-1016 P.E. SCHLEIN, T.G. TRIPPE (UCLA) JP
REANALYSES DATA OF TAHER-ZADEH 63 , BASTIEN 63 AND ALL PUBLISHED
LAMBDA PI CROSS SECTION DATA IN THE LIGHT OF THE NOW KNOWN
Y*1(1765) . REVERSES THE MODEL-DEPENDENT CONCLUSION OF TAHER-
ZADEH ON THE PREFERRED JP ASSIGNMENT (FROM 3 2+ TO 3 (2-).)
SMART 66 PRL 17 556 W M SMART,A KERNAN,G E KALMUS,R P ELY (LRL)IJP
ARMENTER 67 NP B3 592 ARMENTEROS,FERRO-LUZZI+ (CERN,HEID,SACLAY)
PREVOST 71 AMSTERDAM CONF + CHS COLLABORATION (CERN+HEID+SACL)

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Σ(1670) BUMPS →

51 Y*1(1670, JP=) I=1 PROD. AND CROSS SECT. EXPS.

SEE NOTE PRECEDING Y*1(1670)
PROBABLY THERE ARE TWO STATES AT SAME MASS WITH SAME
QUANTUM NUMBERS, ONE DECAYING INTO SIGMA PI AND LAMBDA
PI, THE OTHER INTO Y*0(1405) PI.

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51 Y*1(1670) MASS (MEV) (PROD. EXP.)

M (1685.0) ALEXANDER 62 HBC -0 PI-P 2-2.2 BEV/C
M 1660.0 10.0 ALVAREZ 63 HBC + K-P 1.51 BEV/C
M (1665.0) (5.0) BUGG 68 CNTR K-P, D TOTAL C.S
M P 70(1661.) (9.) PRIMER 68 HBC + K-P 4.6-5. GEV/C 7/68
M P SEE BARNES 69 FOR NEW ANALYSIS OF DATA (3 TIMES MORE DATA) 10/69
M 1670.0 6.0 AGUILAR 70 HBC SIG.PI K-P 4 GEV 5/70
M 1668.0 10.0 AGUILAR 70 HBC SIG.2PI K-P 4GEV 5/70
M 1665. 1.0 APSELL 74 HBC K- P 2.87 GEV/C 4/75
M 1200 1688+/-2. OR 1683+/-5. BERTHON 74 HBC 0 QUASI 2 BODY CS 4/75
M 5 1670. 4. CARROLL 76 DPWA I=1 TOTAL CS 2/77
M 5 TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.23 2/77
M 2 1675. 10. HEPP1 76 DBC - K-N 1.6-1.75 GEV 2/77
M 2 ENHANCEMENTS IN SIG PI AND SIG PI PI CHANNEL CROSS SECTIONS. 2/77
M 1655. TO 1677. TIMMERMA 76 HBC + K- P 4.2 GEV/C 2/77
M . . . .
M AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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51 Y*1(1670) MASS (MEV) (PROD. EXP.)

W (45.0) ALEXANDER 62 HBC -0
W 40.0 10.0 ALVAREZ 63 HBC +
W (30.0) (15.0) BUGG 68 CNTR 11/66
W P 70 (60.) (20.) PRIMER 68 HBC + K-P 4.6-5. GEV/C 7/68
W 110.0 12.0 AGUILAR 70 HBC SIG.PI K-P 4 GEV 5/70
W 135.0 40.0 30.0 AGUILAR 70 HBC SIG.2PI K-P 4GEV 5/70
W 67. 2.4 APSELL 74 HBC K- P 2.87 GEV/C 4/75
W SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
W 5 (52.) CARROLL 76 DPWA I=1 TOTAL CS 2/77
W 48. TO 63. TIMMERMA 76 HBC + K- P 4.2 GEV/C 2/77
W . . . .
W AVERAGE MEANINGLESS (SCALE FACTOR = 3.2)

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51 Y*1(1670) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	Y*1(1670) INTO KBAR N	497+ 939
P2	Y*1(1670) INTO LAMBDA PI	1115+ 139
P3	Y*1(1670) INTO SIGMA PI	1197+ 139
P4	Y*1(1670) INTO LAMBDA PI PI	1115+ 139+ 139
P5	Y*1(1670) INTO SIGMA PI PI	1197+ 139+ 139
P6	Y*1(1670) INTO Y*1(1385) PI	1384+ 139
P7	Y*1(1670) INTO Y*0(1405) PI	1405+ 139

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51 Y*1(1670) BRANCHING RATIOS (PROD. EXP.)

R1 Y*1(1670) INTO (KBAR N)/(SIGMA PI) (P1)/(P3)
R1 0 (0.19) OR LESS ALVAREZ 63 HBC + K-P 1.15 BEV/C
R1 (0.5)+- .25 OR MORE SMITH 63 HBC -0
R1 (0.6) OR LESS LONDON 66 HBC + K-P 2.25 BEV/C 7/66
R1 (0.025) BUGG 68 CNTR 0 ASSUMING J=3/2 11/66
R1 0 (0.24) OR LESS PRIMER 68 HBC + K-P 4.6-5. GEV/C 7/68
R1 (0.26) OR LESS BARNES 69 HBC + K-P 3.9-5 GEV/C 10/69
R1 (0.2) OR LESS AGUILAR 70 HBC 5/70
R1 (0.10) OR LESS BERTHON 74 HBC 0 QUASI 2 BODY CS 4/75
R1 (.03) OR LESS TIMMERMA 76 HBC + K- P 4.2 GEV/C 2/77

R2 Y*1(1670) INTO (LAMB.PI)/(SIG PI) (P2)/(P3)
R2 130 (1.20) ALVAREZ 63 HBC + K-P 1.15 BEV/C
R2 (1.2) SMITH 63 HBC -0
R2 0.15 0.07 HUWE 64 HBC +
R2 0.6 OR LESS LONDON 66 HBC + K-P 2.25 BEV/C 7/66
R2 33 0.11 0.06 BUTTON-S 68 HBC + K-P AT 1.7 GEV/C 10/69
R2 P 0 (0.) PRIMER 68 HBC + K-P 3.9-5 GEV/C 10/69
R2 P PRIMER 68 ASSUMED THIS DECAY TO BE ALL Y*(1690)- SEE BARNES 69 FOR
R2 P NEW INTERPRATATION OF DATA.(3 TIMES MORE DATA) -
R2 0.45 0.15 BARNES 69 HBC + K-P 3.9-5 GEV/C 10/69
R2 (.55) (.11) BERTHON 74 HBC 0 QUASI 2 BODY CS 4/75
R2 .76 .09 ESTES 74 HBC 0 K-P,2.1+2.6GEV/C 11/75
R2 (.45)+/- .07 OR LESS TIMMERMA 76 HBC + K- P 4.2 GEV/C 2/77
R2 . . . .
R2 AVERAGE MEANINGLESS (SCALE FACTOR = 3.7)

R3 Y*1(1670) INTO (LAMB. PI PI)/(SIG PI) (P4)/(P3)
R3 90 (0.56) ALVAREZ 63 HBC + K-P 1.15 BEV/C
R3 (0.17) SMITH 63 HBC -0
R3 (0.6) OR LESS LONDON 66 HBC + K-P AT 2.25 BEV/C 7/66

R4 Y*1(1670) INTO (SIGMA PI PI)/(SIG PI) (P5)/(P3)
R4 180 (0.56) ALVAREZ 63 HBC + K-P 1.15 BEV/C
R4 B LARGEST AT SMALL ANGLES ESTES 74 HBC 0 K-P,2.1+2.6GEV/C 11/75
R4 2 (0.2)OR LESS HEPP1 76 DBC - K-N 1.6-1.75 GEV 2/77

R5 Y*1(1670) INTO (Y*0(1405) PI)/(SIG PI) (P7)/(P3)
R5 50 3. 1.6 LONDON 66 HBC + K-P 2.25 BEV/C 7/66
R5 P 17 (0.58) (0.20) PRIMER 68 HBC + K-P 4.6-5. GEV/C 7/68
R5 B LARGEST AT SMALL ANGLES ESTES 74 HBC +- K-P 2.1+2.6GEV/C 11/75
R5 BD 1.8+/-0.3 TO 0.02+/-0.07 TIMMERMA 76 HBC + K-P 4.2 GEV/C 11/77
R5 D DEPENDING ON PRODUCTION ANGLE

R6 Y*1(1670) INTO (SIGMA PI)/(SIGMA PI PI) (P3)/(P5)
R6 .4 OR LESS BIRMINGHA 66 HBC + K-P AT 3.5 GEV/C 11/67
R6 0.30 0.15 LONDON 66 HBC + K-P 2.25 GEV/C 7/66
R6 D BETWEEN 2.5 AND 0.24 EBERHARD 69 HBC K-P AT 2.6 GEV/C 9/69
R6 D DEPENDING ON THE PRODUCTION ANGLE
R6 B VARIES WITH PROD. ANGLE APSELL 74 HBC + K-P 2.87 GEV/C 4/75
R6 (1.39) (.16) BERTHON 74 HBC 0 QUASI 2 BODY CS 4/75
R6 B APSELL 74, ESTES 74 AND TIMMERMANS 76 FIND STRONG BRANCHING RATIO
R6 B DEPENDENCE ON PRODUCTION ANGLE, AS IN EARLIER PROD. EXPERIMENTS.

R7 Y*1(1670) INTO (Y*0(1405) PI)/(SIGMA PI PI) (P7)/(P5)
R7 0.90 0.10 0.16 EBERHARD 65 HBC + K-P 2.45 BEV/C 7/66
R7 1.00 .02 APSELL 74 HBC K- P 2.87 GEV/C 4/75
R7 .97 .08 TIMMERMA 76 HBC K- P 4.2 GEV/C 2/77
R7 . . . .
R7 AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R8 Y*1(1670) INTO (Y*0(1405) PI)/(Y*1(1385) PI) (P7)/(P6)
R8 (0.8) OR LESS EBERHARD 65 HBC + K-P 2.45 BEV/C 7/66

R9 Y*1(1670) INTO (LAMBDA PI PI)/(SIGMA PI PI) (P4)/(P5)
R9 0.35 0.2 BIRMINGHA 66 HBC + K-P AT 3.5 GEV/C 11/67

R10 Y*1(1670) INTO (LAMBDA PI)/(SIGMA PI PI) (P2)/(P5)
R10 (.2) OR LESS BIRMINGHA 66 HBC + K-P AT 3.5 GEV/C 11/67

R11 Y*1(1670) INTO (LAMBDA PI)/(LAMBDA PI + SIG PI) (P2)/(P2+P3)
R11 (0.6) OR LESS AGUILAR 70 HBC 5/70

R12 Y*1(1670) INTO (Y*1(1385) PI)/(SIGMA PI) (P6)/(P3) 1/76
R12 (.21)+/- .05 OR LESS TIMMERMA 76 HBC K- P 4.2 GEV/C 2/77

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51 Y*1(1670) QUANTUM NUMBER DETERMINATION (PROD. EXP.)

Q1 JP=3/2+ LEVEQUE 65 HBC INTO Y*(1405)+PI 11/68
Q3 JP=3/2- EBERHARD 67 HBC + INTO Y*(1405) PI 11/68
Q4 400 JP=3/2- BUTTON-SH 68 HBC +- INTO SIGZERO+PI 11/68

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REFERENCES FOR Y*1(1670) (PROD. EXP.)

ALEXANDE 62 CERN CONF 320 ALEXANDER,JACOBS,KALBFLEISCH,MILLER,+ (LRL) I
ALVAREZ 63 PRL 10 184 +ALSTON,FERRO-LUZZI,HUWE, + (LRL) I
SMITH 63 ATHENS CONF 67 G A SMITH (LRL)
HUWE 64 PR 180 1824(1969) D O HUWE (LRL)
EBERHARD 65 PRL 14 466 +SHIVELY,ROSS,SIEGAL,FICENEC, + (LRL,ILL) I

BIRMINGH 66 PR 152 1148 BIRMINGHAM,GLASGOW,I.C.Y OXFORD,RUTHERFORD
LONDON 66 PR 143 1034 +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+ (BNL,SYRA) IJ
BUGG 68 PR 168 1466 +GILMORE,KNIGHT,DAVIES+ (BIRM,CAVE,RHEL)I
BUTTON-S 68 PRL 21 1123 J BUTTON SHAFER (MASA+LRL) JP
PRIMER 68 PRL 20 610 +GOLDBERG,JAEGER,BARNES,DORNAN + (SYRA,BNL)

BARNES 69 BNL 13823 +CHUNG,EISNER,FLAMINIO+ (BNL,SYRA)
EBERHARD 69 PRL 22 200 +FRIEDMAN,PRIPSTEIN,ROSS (LRL)
AGUILAR 70 PRL 25 58 +BARNES, BASSANO, CHUNG, EISNER,+(BNL,SYRA)

APSELL 74 PRD 10 1419 APSELL,FORD,GOUREVITCH+(BRAN,UMD,SYRA,TUFT)I
BERTHON 74 NC 21A 146 BERTHON,TRISTRAM,+ (CDEF+RHEL+SACL+STRB)
ESTES 74 LBL-3827 (THESIS) R. D. ESTES (LBL)

CARROLL 76 PRL 37 806 +CHIANG,KYCIA,LI,MAZUR,MICHAEL+ (BNL)I
HEPP1 76 NP B115 82 +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)I
TIMMERMA 76 NP B112 77 TIMMERMANS,ENGELEN+ (NIJM+CERN+AMST+OXF) JP

PAPERS NOT REFERRED TO IN DATA CARDS

LEVEQUE 65 PL 18 69 + (SACLAY,EPOL,GLASGOW,LOIC,OXF,RHEL) JP
LEE 66 PRL 17 45 Y Y LEE, D D REEDER, R W HARTUNG (WISC) JP
EBERHARD 67 PR 163 1446 +PRIPSTEIN,SHIVELY,KRUSE,SWANSON (LRL,ILL)IJP
MILLER 70 DUKE 229 D H MILLER (REVIEW TALK) (PURDUE)
EBERHARD 73 PURDUE CONF. 247 EBERHARD (LBL)IJP
HUNGERBU 74 PRD 10 2051 HUNGERBUHLER,MAJKA,+ (YALE,FNAL,BNL,PITT)

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Baryons
Σ(1690), Σ(1750)

Data Card Listings
For notation, see key at front of Listings.

Σ(1690) BUMPS

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58  Y*1(1690, JP=     ) I=1          PRODUCTION EXPERIMENTS
SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

SEE NOTE PRECEDING Y*1(1670) LISTINGS, SEEN IN PRO.
EXPERIMENTS ONLY, MAIN DECAY MODE IS LAMBDA PI.

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              58  Y*1(1690) MASS (MEV) (PROD. EXP.)

M       30(1715.0)  (12.0)         COLLEY    67 HBC  + K-P 6 GEV/C       8/67
M   P   60(1694.0)  (24.0)         PRIMER    68 HBC  + K-P 4.6-5 GEV/C   7/68
M   P    SEE Y*1(1670) LISTING-AGUILAR 70 WITH THREE TIMES THE DATA OF
M   P    PRIMER 68  SHOW THAT THEY HAVE NO EVIDENCE FOR Y*(1690)
M    N    (1700.0)   (6.0)         SIMS      68 HBC  - K-N TO LAM PI PI 11/68
M    N   THIS ANALYSIS, WHICH IS DIFFICULT AND REQUIRES SEVERAL ASSUMPTIONS
M    N   AND SHOWS NO UNAMBIGUOUS Y*1(1690) SIGNAL, SUGGESTS JP=5/2+.
M    N   SUCH A Y* WOULD LEAD ALL PREVIOUSLY KNOWN Y* TRAJECTORIES.
M       15(1698.0)  (20.0)         ADERHOLZ  69 HBC  + PI+P 8 GEV/C     12/79*
M       46(1682.0)   (2.0)         BLUMENFEL 69 HBC  + KO LONG + PROTON  9/69
M         (1700.0)  (20.0)         MOTT      69 HBC  + K-P 5.5 GEV/C     9/69
M   F   70(1698.0)  (20.0)         GODDARD   79 HBC  + PI+P 10.3 GEV/C  12/79*
M   S   40(1707.0)  (20.0)         GODDARD   79 HBC  + PI+P 10.3 GEV/C  12/79*
M   F    FROM (LAMBDA PI+) K+ FINAL STATE. J>1/2 NOT REQUIRED BY DATA.
M   S    FROM (LAMBCA PI+) (K PI)+ FINAL STATE. J>1/2 INDICATED, BUT LARGE
M   S    BACKGROUND PRECLUDES DEFINITE CONCLUSION.

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              58  Y*1(1690) WIDTH (MEV) (PROD. EXP.)

W       30 (100.0)  (35.0)             COLLEY    67 HBC  +                   8/67
W   P   60 (105.0)  (35.0)             PRIMER    68 HBC  +                   7/68
W    N      (62.0)  (14.0)             SIMS      68 HBC  - SEE NOTE N ABOVE 11/68
W       15 (142.0)  (40.0)             ADERHOLZ  69 HBC  + PI+P 8 GEV/C     12/79*
W       46  (25.0)  (10.0)             BLUMENFEL 69 HBC  +                   9/69
W          (130.0)  (25.0)             MOTT      69 HBC  +                   9/69
W   F   70 (240.0)  (60.0)             GODDARD   79 HBC  + PI+P 10.3 GEV/C  12/79*
W   S   40 (130.0) (100.0)    (60.0)   GODDARD   79 HBC  + PI+P 10.3 GEV/C  12/79*
             SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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              58  Y*1(1690) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1      Y*1(1690) INTO KBAR N                            497+ 939
P2      Y*1(1690) INTO LAMBDA PI                         1115+ 139
P3      Y*1(1690) INTO SIGMA PI                          1197+ 139
P4      Y*1(1690) INTO Y*1(1385) PI                      1384+ 139
P5      Y*1(1690) INTO LAMBDA PI PI (INCLUDING P4)       1115+ 139+ 139

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              58  Y*1(1690) BRANCHING RATIOS (PROD. EXP.)

R1      Y*1(1690) INTO (KBAR N)/(LAMBDA PI)               (P1)/(P2)
R1      18     0.4      0.25        COLLEY    67 HBC  + 6/30 EVENTS       8/67
R1            (0.2)  OR LESS        MOTT      69 HBC  +                   9/69
R1          SMALL                   GODDARD   79 HBC  + PI+P 10.2 GEV/C  12/79*

R2      Y*1(1690) INTO (SIGMA PI)/(LAMBDA PI)             (P3)/(P2)
R2             0.3      0.3         COLLEY    67 HBC  + 4/30 EVENTS       8/67
R2            (0.4)  OR LESS  CL=.90 MOTT     69 HBC  +                   9/69
R2          SMALL                   GODDARD   79 HBC  + PI+P 10.2 GEV/C  12/79*

R3      Y*1(1690) INTO (Y*1(1385) PI)/(LAMBDA PI)         (P4)/(P2)
R3            (0.5)  OR LESS        MOTT      69 HBC  +                   9/69

R4      Y*1(1690) INTO (LAMBDA PI PI)/(LAMBDA PI)         (P5)/(P2)
R4             0.5      0.25        COLLEY    67 HBC  + 15/30 EVENTS      8/67
R4             2.0      0.6         BLUMENFEL 69 HBC  + 31/15 EVENTS      9/69
R4          . . . . . . . . . .
R4   AVG       0.72     0.53    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
R4   STUDENT   0.67     0.28    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R5      Y*1(1690) INTO (Y*1(1385) PI)/(LAMBDA PI PI)      (P4)/(P5)
R5           SMALL                  COLLEY    67 HBC  +                   8/67
R5           LARGE                  SIMS      68 HBC  - K-N TO L2PI      11/68

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                       REFERENCES FOR Y*1(1690) (PROD. EXP.)

COLLEY    67 PL 24B 489           (BIRM,GLAS,LOIC,MUNICH,OXFORD,RHEL) I
DERRICK   67 PRL 18 266         +FIELDS, LOKEN, AMMAR,  (ARGONNE,NORTHWEST) I
   REPLACED BY MOTT 69.
PRIMER    68 PRL 20 610         +GOLDBERG, JAEGER, BARNES, + (SYRACUSE,BNL) I
SIMS      68 PRL 21 1413        +ALBRIGHT, +            (FSU,TUFTS,BRANDEIS) I

ADERHOLZ  69 NP B11 259         +BARTSCH,SCHULTE+(AACH+BERL+CERN+CRAC+WARS)I
BLUMENFE  69 PL 29B 58          B J BLUMENFELD, G R KALBFLEISCH        (BNL) I
MOTT      69 PR 177 1966        +AMMAR, DAVIS, KROPAC, +(NORTHWEST,ARGONNE) I

GODDARD   79 PR D19 1350        +KEY,LUSTE,PRENTICE,YOON,GORDON+ (TNTO+BNL)I,J

                                PAPERS NOT REFERRED TO IN DATA CARDS

AGUILAR   70 PRL 25 58          AGUILAR-BENITEZ,BARNES,BASSANO+  (BNL+SYRA)
CCOPER    70 NP B23 605         +MANNER,MUSGRAVE,POLLARD,VOYVODIC      (ANL)I

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Σ(1750) S''_{11}

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57  Y*1(1750, JP=1/2-) I=1

              THERE IS EVIDENCE FOR THIS STATE IN MANY PARTIAL-
              WAVE ANALYSES, BUT WITH RATHER WIDE VARIATIONS IN
              THE MASS, WIDTH AND COUPLINGS.  THE LATEST ANALYSES
    INDICATED SIGNIFICANT COUPLINGS TO KBAR N AND LAMBDA PI, AS WELL AS
    SIGMA ETA WHOSE THRESHOLD IS NEARBY AT 1746 MEV (JONES 74).

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              57  Y*1(1750) MASS (MEV)

M          NEAR SIGMA ETA THRESHOLD  CLINE     67 DBC  - K-N TO SIGMA ETA   9/66
M          ABOUT 1750.0              MEYER     67 RVUE                      9/69
M          ABOUT 1730.0              ARMENTERO 70 HDBC -0 K-N TO LAMBDA PI  6/70
M         (1757.0)    (10.0)         CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
M         (1790.)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
M         (1790.0)    (15.0)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72
M         (1716.)     (10.)          BAXTER    73 DPWA  0 K- P TO NEUTRALS 10/74
M         (1785.)     (12.)          CHU       74 DBC   - FIT SIG- ETA CS  10/74
M    1    (1760.)      (5.)          JONES     74 HBC   0 FIT SIGO ETA CS   1/74
M         (1739.)     (10.)          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
M    1  S-WAVE BW FIT TO THRSHLD C.S., NO BKGND. ERRORS STATISTICAL ONLY    1/74
M   A     (1780.)     (30.)          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M   A   FROM SOLUTION 1 OF BAILLON 75.                                    11/75
M   B     (1700.)     (30.)          BAILLON   75 IPWA    KBAR N TO LAM PI  1/76
M   B   FROM SOLUTION 2 OF BAILLON 75.                                     1/76
M         (1697.)     (20.)   (10.)  VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
M         (1730.)                    BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
M    3     1715.       10.           CARROLL   76 DPWA    I=1 TOTAL CS      2/77
M    4     1800. OR 1813.            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    4  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    4  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1770.       15.           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          1770.       10.           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M          . . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 3.0)

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              57  Y*1(1750) WIDTH (MEV)

W          ABOUT 50.0                MEYER     67 RVUE                      9/69
W          ABOUT 80.0                ARMENTERO 70 HDBC -0 K-N TO LAMBDA PI  6/70
W           (55.0)    (10.0)         CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
W           (50.)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
W          (100.0)    (20.0)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W           (60.)     (20.)          BAXTER    73 DPWA  0 K- P TO NEUTRALS 10/74
W           (89.)     (33.)          CHU       74 DBC   - FIT SIG- ETA CS  10/74
W    1      (92.)      (7.)          JONES     74 HBC   0 FIT SIG+ETA CS    1/74
W          (108.)     (20.)          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
W   A      (140.)     (30.)          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W   B      (160.)     (50.)          BAILLCN   75 IPWA    KBAR N TO LAM PI  1/76
W           (66.)     (14.)   (12.)  VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
W          (110.)                    BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
W    3      (10.)                    CARROLL   76 DPWA    I=1 TOTAL CS      2/77
W    4     117. OR 119.              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W           60.        10.           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W          161.        20.           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W          . . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 4.5)

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              57  Y*1(1750) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Y*1(1750) INTO KBAR N                            497+ 939
P2      Y*1(1750) INTO SIGMA ETA                         1197+ 548
P3      Y*1(1750) INTO LAMBDA PI                         1115+ 134
P4      Y*1(1750) INTO SIGMA PI                          1197+ 139
P5      Y*1(1750) INTO SIGMA(1385) PI                     139+1384
P6      Y*1(1750) INTO LAMBDA(1520) PI                    139+1518

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              57  Y*1(1750) BRANCHING RATIOS

R1      Y*1(1750) INTO (KBAR N)/TOTAL                     (P1)
R1            (0.12)    (0.05)       CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
R1            (0.8)                  KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1            (0.45)    (0.05)       LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1    3  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.30   SEEN BY CARROLL 76    2/77
R1    4       (.06)OR .05            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1              .15       .03        RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1              .33       .05        ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1          . . . . . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 3.1)

R2      Y*1(1750) FROM KBAR N INTO SIGMA ETA              SQRT(P1*P2)
R2            SEEN                   CLINE     69 DBC  -  THRESHOLD BUMP    9/69
R2    1       (.23)     (.01)        JONES     74 HBC   0 FIT SIG+ETA CS    1/74

R3      Y*1(1750) FROM KBAR N INTO LAMBDA PI              SQRT(P1*P3)
R3   2        (-0.25)                ARMENTERO 70 IPWA -0 K-N TO LAMBDA PI  6/70
R3   2  PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT) 10/74
R3            (0.09)                 KIM       71 DPWA    K-MATRIX ANAL.    3/71
R3            (0.30)    (0.05)       LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R3            (-.28)    (.05)        BAXTER    73 DPWA  0 K- P TO NEUTRALS 10/74
R3            (-.120)   (.077)       DEVENISH  74         0 FIXED T DISP REL  4/75
R3   A        (-.12)    (.02)        BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R3   B        (-.13)    (.03)        BAILLON   75 IPWA    KBAR N TO LAM PI  1/76
R3            (-.13)    (.04)        VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
R3            (-.12)                 BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
R3    4       (-.10)OR -.09          MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R3             (.04)    (.03)        RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R4      Y*1(1750) FROM KBAR N TO SIGMA PI                 SQRT(P1*P4)
R4            (0.16)                 KIM       71 DPWA    K-MATRIX ANAL.    3/71
R4            (0.13)    (0.02)       LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R4    4       (+.06)OR +.06          MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R4             -.09       .05        RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R5      Y*1(1750) FROM KBAR N TO SIGMA(1385) PI           SQRT(P1*P4)
R5            +.18        .15        PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74

R6      Y*1(1750) FROM KBAR N TO LAMBDA(1520) PI          SQRT(P1*P6)
R6    5         .032      .021       CAMERON   77 DPWA  0 P-WAVE DECAY      1/78
R6    5  ASSUMES LAMBDA(1520) ELASTICITY=.46                                1/78

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                       REFERENCES FOR Y*1(1750)

CLINE     67 PL 25B 41          CLINE, OLSSON                    (WISCONSIN)IJP
MEYER     67 HEIDELBERG C 117   J MEYER  (RAPPORTEUR)                (SACLAY)IJP
ARMENTER  70 DUKE 123           ARMENTEROS, BAILLON, +          (CERN,HEIDEL)IJP
CONFORTO  71 NP  B34  41        +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM       71 PRL 27 356         J K KIM                                (HARV)IJP
   ALSO   70 DUKE 161           J. K. KIM                              (HARV)IJP
LANGBEIN  72 NP B47 477         +WAGNER                                (MPIM)IJP

BAXTER    73 NP B67 125         BAXTER,BUCKINGHAM,CORBETT,DUNN,+   (OXFORD)IJP
CHU       74 NC 20A 35          CHU,BARTLEY,+ (SUNY PLATTSBURGH+TUFTS+BRAN)IJP
JONES     74 NP B73 141         JONES                            (U. CHICAGO)IJP
DEVENISH  74 NP B81 330         DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
PREVOST   74 NP B69 246         PREVOST,BARLOUTAUD,+          (SACL+CERN+HEID)

BAILLCN   75 NP B94 39          P. BAILLON,P. J. LITCHFIELD     (CERN,RHEL)IJP
VANHORN   75 NP B87 145         A. J. VAN HORN                          (LBL)IJP
   ALSO   75 NP B87 157         A. J. VAN HORN                          (LBL)IJP
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Data Card Listings

For notation, see key at front of Listings.

Baryons

Σ(1750), Σ(1765)


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BELLEFON 76 NP B109 129         DE BELLEFON,BERTHON                  (CDEF)IJP
CARROLL  76 PRL 37 806          +CHIANG,KYCIA,LI,MAZUR,MICHAEL+       (BNL)I

CAMERON  77 NP B131 399         +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN   77 NP B127 349         MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
   ALSO  77 NP B126 266         MARTIN,PIDCOCK                        (LOUC)
   ALSO  77 NP B126 285         MARTIN,PIDCOCK                        (LOUC)IJP
RLIC     77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP

ALSTON   78 PR D18 182          +KENNEY,POLLARD,ROSS+         (LBL+MTHO+CERN)IJP
   ALSO  77 PRL 38 1007         ALSTON-GARNJOST,KENNEY        (LBL+MTHO+CERN)IJP

                    PAPERS NOT REFERRED TO IN DATA CARDS

FERRO-LU 66 BERKELEY CONF 183 M FERRO LUZZI  (RAPPORTEUR)             (CERN)
ARMENTER 68 NP B8 183           ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENTER 69 LUND CONF PAPER     ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
HARRISON 70 FSU-HEP 70 3 1      W.C. HARRISON (THESIS)                 (FSU)
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Σ(1765) — 45 Y*1(1765, JP=5/2-) I=1 — D_{15}

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

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                   45  Y*1(1765) MASS (MEV)

M          1765.0      10.0           GALTIERI  63 DBC    0 K-D 1.51 BEV/C
M          1755.0      10.0           ARMENTER  65 HBC    0 K-P TO Y*1520 PI   7/66
M          1760.0      10.0           BELL 1    66 DBC    -  K-N TO Y*1520 PI  7/66
M     N    1768.0       2.0           ARMENT-1  68 DPWA   0 ELASTIC, CH EXCH 11/68
M     N    1768.0       4.0           BUGG      68 CNTR     K-P, D TOTAL     11/66
M          1775.0       7.0           SMART     68 RVUE -0 K-N TO LAMBDA PI   7/68
M          1770.0      10.0           COOL      70 CNTR     K-P, D TOTAL     10/70
M          1765.0      10.0           GALTIERI  70 DPWA   0 K-P TO LAMBDA PI   7/70
M     N    1770.0       3.0           CONFORTO  71 DPWA   0 ELASTIC, CH EXCH  6/70
M         (1765.)                     KIM       71 DPWA     K-MATRIX ANAL.    3/71
M          1758.7       3.9           BARLETTA  72 DPWA   0 KPPI 0.8-1.2GEV  12/72
M          1765.0       9.0           KANE      72 DPWA   0 K-P TO PI SIG    10/71
M     N    1770.0       5.0           LANGBEIN  72 IPWA     MULTICHANNEL     12/72
M          1775.       10.            BAILLON   75 IPWA     KBAR N TO LAM PI 11/75
M          1774.       10.            VANHORN   75 DPWA   0 K- P TO LAM PIO  11/75
M         (1765.)                     BELLEFON  76 IPWA   0 K- P TO LAM PI    2/77
M     1    1772. OR 1777.             MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
M     1  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     1  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1774.        5.            RLIC      77 DPWA     KBAR N MULTICHNL  1/76
M          1777.        5.            ALSTON    78 DPWA     KBAR N ELASTIC    1/78
M     N   ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED  1/71
M           . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                   45  Y*1(1765) WIDTH (MEV)

W            60.0      10.0           GALTIERI  63 DBC    0
W            70.0      20.0           BELL 2    66 DBC    -                  7/66
W           128.0       8.0           ARMENT-1  68 DPWA   0 ELASTIC, CH EXCH 11/68
W           110.0       7.0           BUGG      68 CNTR     K-P,D TOTAL       7/68
W           146.0       9.0           SMART     68 RVUE -0                    7/68
W          (100.0)                    COOL      70 CNTR     K-P, D TOTAL     10/70
W           115.0      10.0           GALTIERI  70 DPWA   0 K-P TO LAMBDA PI  7/70
W           132.0      10.0           CONFORTO  71 DPWA   0 ELASTIC, CH EXCH  6/70
W          (100.)                     KIM       71 DPWA     K-MATRIX ANAL.    3/71
W           107.2      10.9           BARLETTA  72 DPWA   0 LAM(1520)PI CH.  12/72
W           120.0      38.0           KANE      72 DPWA   0 K-P TO PI SIG    10/71
W           123.0      10.0           LANGBEIN  72 IPWA     MULTICHANNEL     12/72
W           125.       15.            BAILLON   75 IPWA     KBAR N TO LAM PI 11/75
W           146.       18.            VANHORN   75 DPWA   0 K- P TO LAM PIO  11/75
W          (120.)                     BELLEFON  76 IPWA   0 K- P TO LAM PI    2/77
W     1     102. OR 103.              MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
W           130.       10.            RLIC      77 DPWA     KBAR N MULTICHNL  1/76
W           116.       10.            ALSTON    78 DPWA     KBAR N ELASTIC    1/78
W           . . . . . . . . .
W    AVG    117.4       6.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
W    STUDENT 120.4      3.7     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                (SEE IDEOGRAM BELOW )
```
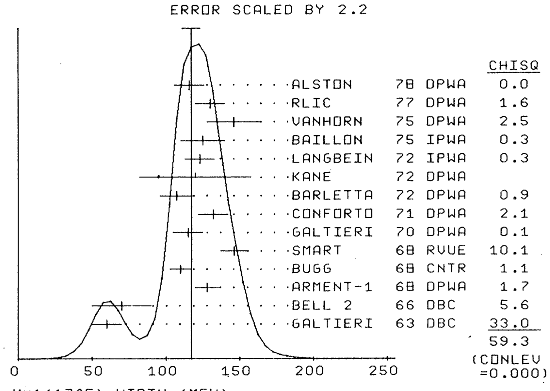

WEIGHTED AVERAGE = 117.4 ± 6.2
ERROR SCALED BY 2.2



Y*1(1765) WIDTH (MEV)

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                45  Y*1(1765) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1        Y*1(1765) INTO KBAR N                          497+ 939
P2        Y*1(1765) INTO LAMBDA PI                      1115+ 134
P3        Y*1(1765) INTO Y*0(1520) PI                   1518+ 139
P4        Y*1(1765) INTO Y*1(1385) PI D-WAVE             139+1384
P5        Y*1(1765) INTO SIGMA PI                       1197+ 139
P6        Y*1(1765) INTO SIGMA ETA                      1197+ 548
P7        Y*1(1765) INTO SIGMA PI PI                    1197+ 139+ 139

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

```
       P 1        P 2        P 3        P 4        P 5        P 6
P 1  .4133+-.0138
P 2   -.0510   .1400+-.0130
P 3   -.3873    -.0146   .1929+-.0331
P 4   -.2953     .0151     .1141   .0859+-.0090
P 5   -.1125     .0057     .0434     .0332   .0145+-.0044
P 6    .0836    -.3500    -.8416    -.2638    -.1350   .1534+-.0342

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                45  Y*1(1765) BRANCHING RATIOS

     ERRORS QUOTED BY EXPERIMENTERS DO NOT INCLUDE UNCERTAINTY DUE
     TO PARAMETRIZATION USED IN THE P.W.A.  THEY SHOULD BE INCREASED.

R1       Y*1(1765) INTO (KBAR N)/TOTAL                        (P1)
R1            (0.6)                   GALTIERI  63 HBC    0 K-P RVUE
R1             0.53     0.09          UHLIG     67 HBC    0                  9/66
R1             0.45     0.01          ARMENT-1  68 DPWA   0 ELASTIC, CH EXCH 11/68
R1            (0.37)                  BUGG      68 CNTR                     11/66
R1             0.36     0.02          BRICMAN1  70 DPWA     SIGTOT,ELAS,CHEX  1/71
R1            (0.4)                   COOL      70 CNTR     K-P, D TOTAL     10/70
R1             0.36     0.02          CONFORTO  71 DPWA   0 ELASTIC, CH EXCH  6/70
R1            (0.42)                  KIM       71 DPWA     K-MATRIX ANAL.    3/71
R1             0.39     0.01          LANGBEIN  72 IPWA     MULTICHANNEL     12/72
R1    1       (.37)OR .36             MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
R1              .41      .03          RLIC      77 DPWA     KBAR N MULTICHNL  1/76
R1              .37      .03          ALSTON    78 DPWA     KBAR N ELASTIC    1/78
R1           . . . . . . . . .
R1   AVG       0.407    0.016   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.6)
R1   STUDENT   0.3930   0.0093  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1   FIT       0.413    0.014  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.4)
                                (SEE IDEOGRAM BELOW )
```
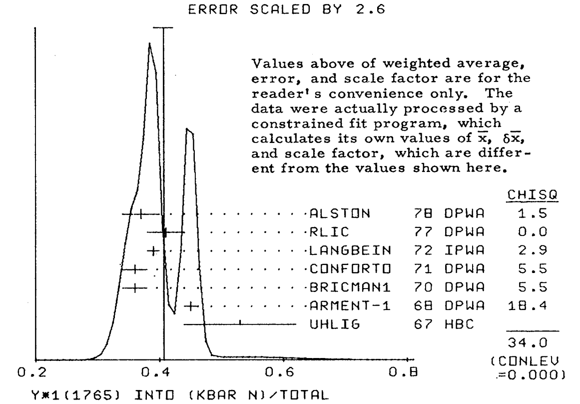

WEIGHTED AVERAGE = 0.407 ± 0.016
ERROR SCALED BY 2.6



Y*1(1765) INTO (KBAR N)/TOTAL

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R2       Y*1(1765) FROM KBAR N INTO LAMBDA PI                 SQRT(P1*P2)
R2            -0.266    0.017          SMART     68 DPWA -0 K-N TO LAMBDA PI   7/68
R2            -0.22     0.03           GALTIERI  70 DPWA  0 K-P TO LAMBDA PI   7/70
R2            (0.30)                   KIM       71 DPWA    K-MATRIX ANAL.     3/71
R2             0.15     0.04           LANGBEIN  72 IPWA    MULTICHANNEL      12/72
R2             -.259     .048          DEVENISH  74          0 FIXED T DISP REL 4/75
R2             -.25      .02           BAILLON   75 IPWA    KBAR N TO LAM PI  11/75
R2             -.28      .04      .05  VANHORN   75 DPWA  0 K- P TO LAM PIO   11/75
R2            (-.30)                   BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77
R2    1       (-.29)OR -.28            MARTIN    77 DPWA    KBAR N MULTICHNL  11/77
R2             -.28      .03           RLIC      77 DPWA    KBAR N MULTICHNL   1/76
R2           . . . . . . . . .
R2   AVG MOD   0.251    0.013    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R2   STUDENT   0.253    0.012    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2   FIT       0.241    0.012   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R3       Y*1(1765) FROM KBAR N INTO Y*0(1520) PI              SQRT(P1*P3)
R3             0.27     0.03           ARMENTERO 65 HBC    0 K-P TO Y*1520 PI  9/66
R3             0.31     0.02           BARLETTA  72 DPWA   0 K-P TO Y*1520 PI 12/72
R3    2       -0.305     .010          CAMERON   77 DPWA   0 K-P TO L(1520)PI  1/78
R3    2   LISTED RATE COMBINES P- AND F-WAVE DECAYS AND ASSUMES LAMBDA(1520)   1/78
R3    2   ELASTICITY=.46. THE CAMERON 77 RESULTS FOR THE SEPARATE P- AND       1/78
R3    2   F-WAVE DECAYS ARE -0.303+/-.010 AND -0.037+/-.014, RESPECTIVELY.    12/79*
R3    2   THE SIGNS ARE CHANGED HERE TO BE IN ACCORD WITH THE BARYON-FIRST    12/79*
R3    2   CONVENTION.                                                          12/79*
R3           . . . . . . . . .
R3   AVG MOD   0.3031   0.0086   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3   STUDENT   0.3033   0.0093   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3   FIT       0.282    0.023   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.9)
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Baryons

Σ(1765), Σ(1770), Σ(1840)

Data Card Listings

For notation, see key at front of Listings.

```
R4      Y*1(1765) FROM KBAR N TO Y*1(1385) PI D-WAVE       SQRT(P1*P4)
R4  A         (0.24)    (0.03)            ARMENT-2  67 HBC    0 K-P TO LAM PI PI   8/67
R4  S         (0.32)    (0.06)            SIMS      68 DBC  -  K-N TO LAM PI PI  11/68
R4  S   SIMS 68 USES ONLY CROSS-SECT. DATA. RESULT USED AS UPPER LIMIT ONLY   3/72
R4             +.20       .02             PREVOST   74 DPWA 0-  K-N TO S(1385)PI  10/74
R4   2         -.184      .011            CAMERON   78 DPWA  0 K-P  TO S(1385)PI   1/78
R4   2  CAMERON  78 UPPER LIMIT ON G-WAVE DECAY IS .03                              1/78
R4            . . . . . . . . . .
R4  AVG MOD    0.1877    0.0096   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4  STUDENT    0.188     0.011    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R4  FIT        0.1884    0.0094 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5      Y*1(1765) FROM KBAR N INTO SIGMA PI                 SQRT(P1*P5)
R5            +0.07      0.02             ARMENTERO 67 DPWA  0 K-P TO SIGMA PI   10/74
R5            +0.06      0.03             GALTIERI  70 DPWA  0 K-P TO SIGMA PI    7/70
R5            (0.09)                      KIM       71 DPWA    K-MATRIX ANAL.     3/71
R5            +0.074     0.017            KANE      72 DPWA  0 K-P TO PI SIG     10/71
R5             0.09  OR LESS              LANGBEIN  72 IPWA    MULTICHANNEL      12/72
R5   1        (+.08)OR +.08               MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R5             +.13       .02             RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R5            . . . . . . . . . .
R5  AVG        0.086     0.015    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
R5  STUDENT    0.082     0.013    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R5  FIT        0.077     0.012  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R6      Y*1(1765) INTO (LAMBDA PI)/(KBAR N)                 (P2)/(P1)
R6             0.33      0.05             UHLIG     67 HBC   0 K-P,.9 GEV/C        9/66
R6            . . . . . . . . . .
R6  FIT        0.339     0.034  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R7      Y*1(1765) INTO (Y*0(1520)PI)/(KBAR N)               (P3)/(P1)
R7             0.28      0.05             UHLIG     67 HBC   0 K-P,.9 GEV/C        9/66
R7            . . . . . . . . . .
R7  FIT        0.467     0.087  FROM FIT (ERROR INCLUDES SCALE FACTOR CF 3.2)

R8      Y*1(1765) INTO (Y*1(1385)PI)/(KBAR N)               (P4)/(P1)
R8             0.25      0.09             UHLIG     67 HBC   0 K-P,.9 GEV/C        9/66
R8            . . . . . . . . . .
R8  FIT        0.208     0.025  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R9      Y*1(1765) INTO (SIGMA PI PI)/TOTAL                  (P7)
R9   P        (0.12)                      ARMENT-2  68 HDBC -0 K-N TO SIG PI PI 11/68
R9   P   FOR ABOUT 3/4 OF THIS, THE SIGMA PI SYSTEM HAS I=0 AND IS ALMOST
R9   P ENTIRELY Y*0(1520).  FOR THE OTHER 1/4, THE SIGMA PI HAS I=1.  THIS
R9   P IS ABOUT WHAT IS EXPECTED FROM THE KNOWN RATE Y*1(1765) TO Y*1(1385)
R9   P PI, AS SEEN IN LAMBDA PI PI.

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REFERENCES FOR Y*1(1765)


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GALTIERI 63 PL 6 296              A BARBARO-GALTIERI,A HUSSAIN,RD TRIPP (LRL)IJ
ARMENTER 65 PL 19 338             ARMENTEROS, +        (CERN,HEIDELBERG,SACLAY)IJP
BELL 1   66 PRL 16 203            R B BELL, R W BIRGE, Y-L PAN, R T PU  (LRL)IJP
BELL 2   66 UCRL-16936 THESIS R B BELL                                  (LRL)IJP
ARMENTER 67 PL 24B 198            ARMENTEROS,FERRO-LUZZI+  (CERN,HEID,SACLAYI)P
ARMENT-2 67 ZEIT.PHYS.202 486 ARMENTEROS,FERRO-LUZZI+  (CERN,HEID,SACLAY)
UHLIG    67 PR 155 1448           +CHARLTON,CCNDON,GLASSER,YODH, +   (UMD,NRL)

ARMENT-1 68 NP B8 195             ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-2 68 NP B8 216             ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY) I
BUGG     68 PR 168 1466           +GILMORE,KNIGHT,DAVIES+    (BIRM,CAVE,RHEL)I
SIMS     68 PRL 21 1413           SIMS,ALBRIGHT,BARTLEY,MEER+ (FSU,TUFT,BRAN)
SMART    68 PR 169 1330           W M SMART                             (LRL)IJP

BRICMAN1 70 PL 33B 511            +FERRO-LUZZI,LAGNAUX                  (CERN)
COOL     70 PR D1 1887            +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
GALTIERI 70 DUKE CCNF 173         A BARBARO-GALTIERI                    (LRL)IJP

CCNFCRTO 71 NP  B34  41           +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM      71 PRL 27 356            J K KIM                              (HARV)IJP
    ALSO 70 DUKE 161              J. K. KIM                            (HARV)IJP

BARLETTA 72 NP B40 45             W.A. BARLETTA                         (EFI) IJP
KANE     72 PR D5 1583            D F KANE                              (LBL)IJP
LANGBEIN 72 NP B47 477            +WAGNER                              (MPIM)IJP
DEVENISH 74 NP B81 330            DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LCUC)
PREVCST  74 NP B69 246            PREVOST,BARLOUTAUD,+        (SACL+CERN+HEID)

BAILLON  75 NP B94 39             P. BAILLON,P. J. LITCHFIELD     (CERN,RHEL)IJP
VANHORN  75 NP B87 145            A. J. VAN HORN                        (LBL)IJP
    ALSO 75 NP B87 157            A. J. VAN HORN                        (LBL)IJP

BELLEFCN 76 NP B109 129           DE BELLEFON,BERTHON                  (CDEF)IJP
CAMERON  77 NP B131 399           +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN   77 NP B127 349           MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266           MARTIN,PIDCOCK                       (LOUC)
    ALSO 77 NP B126 285           MARTIN,PIDCOCK                       (LOUC)IJP
RLIC     77 NP B119 362           GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP

ALSTCN   78 PR D18 182            +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007           ALSTON-GARNJOST,KENNEY       (LBL+MTHO+CERN)IJP
CAMERCN  78 NP B143 189           +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP

                                  PAPERS NOT REFERRED TO IN DATA CARDS

FENSTER  66 PRL 17 841            +GELFAND,HARMSEN,L-SETTI,+ (CHIC,ANL(CERN))IJP
      -- FENSTER 66 IS SUPERSEDED BY BARLETTA 72
CONFORTO 68 NP B8 265             +HARMSEN, LASINSKI, +      (CHICAGO,HEIDEL)IJP
    SUPERSEDED BY CONFORTO 71.
HARRISON 70 FSU-HEP 70 3 1    W.C. HARRISCN (THESIS)                    (FSU)
PREVOST  71  AMSTERDAM CONF   + CHS COLLABORATION              (CERN+HEID+SACL)
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Σ(1770)

100   Y*1(1770, JP=1/2+) I=1 P''_{11}

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                  100  Y*1(1770) MASS  (MEV)

M          (1772.0)                       KANE      72 DPWA    K-P TO SIGMA PI  11/77
M    1      1770.      20.                BAILLON   75 IPWA    KBAR N TO PI LAM 11/75
M    1  FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2.                1/76
M           1738.      10.                RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M           . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

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                  100  Y*1(1770) WIDTH (MEV)

W          (80.)                          KANE      72 DPWA    K-P TO SIGMA PI  11/77
W    1      80.        30.                BAILLON   75 IPWA    KBAR N TO PI LAM 11/75
W           72.        10.                RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W           . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                  100  Y*1(1770) PARTIAL DECAY MODES

                                                               DECAY MASSES
P1      Y*1(1770) INTO KBAR N                                 497+ 939
P2      Y*1(1770) INTO LAMBDA PI                             1115+ 139
P3      Y*1(1770) INTO SIGMA PI                              1197+ 139

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                  100  Y*1(1770) BRANCHING RATIOS

R1      Y*1(1770) FROM KBAR N INTO LAMBDA PI                 SQRT(P1*P2)
R1   1         -.08       .02             BAILLCN   75 IPWA    KBAR N TO PI LAM 11/75
R1             LESS THAN .04              RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R2      Y*1(1770) INTO (KBAR N)/TOTAL                        (P1)                1/76
R2              .14       .04             RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3      Y*1(1770) FROM KBAR N INTO SIGMA PI                  SQRT(P1*P3)         1/76
R3           (-.108)                      KANE      72 DPWA    K-P TO SIGMA PI  11/77
R3             LESS THAN .04              RLIC      77 DPWA    KBAR N MULTICHNL  1/76

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REFERENCES FOR Y*1(1770)


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KANE     72 PR D5 1583            D F KANE                              (LBL)
BAILLON  75 NP B94 39             P. BAILLON,P. J. LITCHFIELD     (CERN,RHEL)IJP
RLIC     77 NP B119 362           GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
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Σ(1840)

01   Y*1(1840, JP=3/2+) I=1 P''_{13}

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                  SEE THE MINI-REVIEWS PRECEDING THE Y*0'S.

                  FOR THE TIME BEING, WE LIST ALL RESONANCE CLAIMS IN THE
    P13 WAVE IN THE 1700-1900 MEV MASS REGION TOGETHER UNDER THIS HEADING.

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                  01  Y*1(1840) MASS (MEV)

M           1840.0     (10.0)             LANGBEIN  72 IPWA    MULTICHANNEL     12/72
M    1     (1720.)     (30.)              BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M    1  FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2.                1/76
M           1925.      (200.)             VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
M     2     1798. OR 1802.                MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M     2  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     2  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.

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                  01  Y*1(1840) WIDTH (MEV)

W           120.0      (10.0)             LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W    1     (120.)      (30.)              BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W            65.       (50.)     (20.)    VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
W     2      93. OR 93.                   MARTIN    77 DPWA    KBAR N MULTICHNL 11/77

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                  01  Y*1(1840) PARTIAL DECAY MODES

                                                               DECAY MASSES
P1      Y*1(1840) INTO KBAR N                                 497+ 939
P2      Y*1(1840) INTO SIGMA PI                              1197+ 139
P3      Y*1(1840) INTO LAMBDA PI                             1115+ 134

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                  01  Y*1(1840) BRANCHING RATIOS

R1      Y*1(1840) INTO (KBAR N)/TOTAL                        (P1)
R1             0.37    (0.13)             LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1    2       (0.0)OR(0.0)                MARTIN    77 DPWA    KBAR N MULTICHNL 11/77

R2      Y*1(1840) FROM KBAR N INTO SIGMA PI                  SQRT(P1*P2)
R2             0.15    (0.04)             LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R2    2       (-.04)OR -.04               MARTIN    77 DPWA    KBAR N MULTICHNL 11/77

R3      Y*1(1840) FROM KBAR N INTO LAMBDA PI                 SQRT(P1*P3)
R3             0.20    (0.04)             LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R3             +.122     .078             DEVENISH  74       0 FIXED T DISP REL  4/75
R3   1        (+.11)   (.02)              BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R3             +.06    (.04)              VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
R3    2       (+.03)OR +.03               MARTIN    77 DPWA    KBAR N MULTICHNL 11/77

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REFERENCES FOR Y*1(1840)


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LANGBEIN 72 NP B47 477            +WAGNER                              (MPIM)IJP
DEVENISH 74 NP B81 330            DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
BAILLON  75 NP B94 39             P. BAILLON,P. J. LITCHFIELD     (CERN,RHEL)IJP
VANHORN  75 NP B87 145            A. J. VAN HORN                        (LBL)IJP
    ALSO 75 NP B87 157            A. J. VAN HORN                        (LBL)IJP

MARTIN   77 NP B127 349           MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266           MARTIN,PIDCOCK                       (LCUC)
    ALSO 77 NP B126 285           MARTIN,PIDCOCK                       (LOUC)IJP
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Σ(1880)

67 Y*1(1880, JP=1/2+) I=1

P'''_{11}

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SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

A RESONANCE IS SUGGESTED BY SEVERAL PARTIAL-WAVE
ANALYSES ACROSS THIS REGION, BUT WITH WIDE VARIATIONS
IN THE MASS AND OTHER PARAMETERS. WE LIST HERE
ALL CLAIMS WHICH LIE WELL ABOVE THE Y*1(1770).

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67 Y*1(1880) MASS (MEV)

M 1882.0 40.0 SMART 68 DPWA -0 K- N TO LAM PI 7/68
M (1850.0) BAILEY 69 DPWA 0 ELASTIC, CH EXCH 10/70
M ABOUT 1850.0 ARMENTERO 70 IPWA -0 ELASTIC, CH EXCH 6/70
M 1950.0 50.0 GALTIERI 70 DPWA -0 K- N TO LAM PI 7/70
M 1920.0 30.0 LITCHFIEL 70 DPWA -0 K- N TO LAM PI 6/70
M 2 (1898.) LEA 73 DPWA MULTICHNL K-MTRX 9/73
M 2 ONLY UNCONSTRAINED STATES FROM TABLE 1 OF LEA73 ARE IN LISTINGS. 9/73
M 1 (1960.) (30.) BAILLON 75 IPWA KBAR N TO LAM PI 11/75
M 1 FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2. 1/76
M 1985. 50. VANHORN 75 DPWA 0 K- P TO LAM PIO 11/75
M 3 1847. OR 1863. MARTIN 77 DPWA KBAR N MULTICHNL 11/77
M 3 THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESCNANCE
M 3 PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M 1870.0 10.0 CAMERON2 78 DPWA K-P TO K*(890) N 12/79*
M . . . .
M AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

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67 Y*1(1880) WIDTH (MEV)

W 222.0 150.0 SMART 68 DPWA -0 K- N TO LAM PI 7/68
W (200.0) BAILEY 69 DPWA 0 ELASTIC, CH EXCH 10/70
W ABOUT 30.0 ARMENTERO 70 IPWA -0 ELASTIC, CH EXCH 6/70
W 200.0 50.0 GALTIERI 70 DPWA -0 K- N TO LAM PI 7/70
W 170.0 40.0 LITCHFIEL 70 DPWA -0 K- N TO LAM PI 6/70
W 2 (222.2) LEA 73 DPWA MULTICHNL K-MTRX 9/73
W 1 (260.) (40.) BAILLON 75 IPWA KBAR N TO LAM PI 11/75
W 220. 140. VANHORN 75 DPWA 0 K- P TO LAM PIO 11/75
W 3 216. OR 220. MARTIN 77 DPWA KBAR N MULTICHNL 11/77
W 80.0 10.0 CAMERON2 78 DPWA K-P TO K*(890) N 12/79*
W . . . .
W AVERAGE MEANINGLESS (SCALE FACTOR = 2.2)

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67 Y*1(1880) PARTIAL DECAY MODES

DECAY MASSES
P1 Y*1(1880) INTO KBAR N 497+ 939
P2 Y*1(1880) INTO LAMBDA PI 1115+ 134
P3 Y*1(1880) INTO SIGMA PI 1197+ 139
P4 Y*1(1880) INTO N K*(890), P1 WAVE 939+ 892
P5 Y*1(1880) INTO N K*(890), P3 WAVE 939+ 892

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67 Y*1(1880) BRANCHING RATIOS

R1 Y*1(1880) INTO (KBAR N)/TOTAL (P1)
R1 (0.22) BAILEY 69 DPWA 0 ELASTIC, CH EXCH 10/70
R1 (0.20) ARMENTERO 70 IPWA -0 ELASTIC, CH EXCH 6/70
R1 2 (.31) LEA 73 DPWA MULTICHNL K-MTRX 9/73
R1 3 (.27)OR .27 MARTIN 77 DPWA KBAR N MULTICHNL 11/77

R2 Y*1(1880) FROM KBAR N INTO LAMBDA PI SQRT(P1*P2)
R2 -0.11 0.03 SMART 68 DPWA -0 K- N TO LAM PI 7/68
R2 -0.09 0.04 GALTIERI 70 DPWA -0 K- N TO LAM PI 7/70
R2 -0.14 0.03 LITCHFIEL 70 DPWA -0 K- N TO LAM PI 6/70
R2 2 (-.30) LEA 73 DPWA MULTICHNL K-MTRX 9/73
R2 -.169 .119 DEVENISH 74 0 FIXED T DISP REL 4/75
R2 1 (-.12) (.02) BAILLON 75 IPWA KBAR N TO LAM PI 11/75
R2 +.05 .07 .02 VANHORN 75 DPWA 0 K- P TO LAM PIO 11/75
R2 3 (-.24)OR -.24 MARTIN 77 DPWA KBAR N MULTICHNL 11/77
R2 . . . .
R2 AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R3 Y*1(1880) FROM KBAR N TO SIGMA PI SQRT(P1*P3) 9/73
R3 2 NOT SEEN LEA 73 DPWA MULTICHNL K-MTRX 9/73
R3 3 (+.30)OR +.29 MARTIN 77 DPWA KBAR N MULTICHNL 11/77

R4 Y*1(1880) FROM KBAR N INTO N K*(890), P1 WAVE SQRT(P1*P4)
R4 4 -0.05 0.03 CAMERON2 78 DPWA K-P TO K*N 12/79*
R4 4 THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST 12/79*
R4 4 CONVENTION. 12/79*

R5 Y*1(1880) FROM KBAR N INTO N K*(890), P3 WAVE SQRT(P1*P5)
R5 +0.11 0.03 CAMERON2 78 DPWA K-P TO K*N 12/79*

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REFERENCES FOR Y*1(1880)

SMART 68 PR 169 1330 W M SMART (LRL)IJP
BAILEY 69 THESIS UCRL-50617 DAVID SAAL BAILEY (LRL LIVERMORE)IJP
ARMENTER 70 DUKE CONF 123 ARMENTEROS, BAILLON, + (CERN, HEIDEL)IJP
GALTIERI 70 DUKE CCNF 173 A BARBARO-GALTIERI (LRL)IJP
LITCHFIE 70 NP B22 269 P J LITCHFIELD (RUTHERFORD)IJP

LEA 73 NP B56 77 +MARTIN,MOORHOUSE+ (RHEL+LOUC+GLAS+AARHUS)IJP
DEVENISH 74 NP B81 330 DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LCUC)
BAILLON 75 NP B94 39 P. BAILLON,P. J. LITCHFIELD (CERN,RHEL)IJP
VANHORN 75 NP B87 145 A. J. VAN HORN (LBL)IJP
ALSO 75 NP B87 157 A. J. VAN HORN (LBL)IJP

MARTIN 77 NP B127 349 MARTIN,PIDCOCK,MOORHOUSE (LOUC+GLAS)IJP
ALSO 77 NP B126 266 MARTIN,PIDCOCK (LOUC)
ALSO 77 NP B126 285 MARTIN,PIDCOCK (LCUC)IJP
CAMERON2 78 NP B146 327 +FRANEK,GOPAL,KALMUS,MC PHERSON,+(RHEL+LCIC)IJP

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Σ(1915)

46 Y*1(1915, JP=5/2+) I=1

F'_{15}

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THIS RESONANCE WAS FIRST SEEN IN THE TOTAL-CROSS-SEC-
TION MEASUREMENTS OF COOL 66. IN THIS ENTRY, HOWEVER,
WE LIST ONLY THE RESULTS FROM PARTIAL-WAVE ANALYSES.
SEE THE NEXT ENTRY FOR THE PARAMETERS OF PEAKS SEEN AROUND 1900-1950
MEV IN CROSS SECTIONS AND INVARIANT-MASS DISTRIBUTIONS. WE MAKE THIS
SEPARATION BECAUSE ONLY THE PARTIAL-WAVE ANALYSES ISOLATE THE F15 WAVE.
SEE ALSO THE NOTE TO THE NEXT ENTRY.

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46 Y*1(1915) MASS (MEV)

M 1902.0 11.0 SMART 68 DPWA -0 K-N TO LAMBDA PI 7/68
M 1910.0 20.0 BERTHON 70 DPWA 0 K-P TO LAMBDA PI 7/70
M 1900.0 15.0 BERTHON1 70 DPWA 0 K-P TO SIGMA PI 10/70
M N 1936.0 (3.0) BRICMAN1 70 DPWA SIGTOT,ELAS,CHEX 1/71
M 1903.0 10.0 COX 70 DPWA - K-N TO LAMBDA PI 6/70
M 1905.0 30.0 GALTIERI 70 DPWA 0 K-P TO LAMBDA PI 7/70
M 1895.0 10.0 LITCHFIEL 70 DPWA -0 K-N TO LAMBDA PI 6/70
M 1910. 15. LITCHFIE 71 DPWA K-P TO KBAR N .10/71
M 1925.0 8.0 KANE 72 DPWA 0 K-P TO PI SIG 10/71
M 1920. 30. BAILLON 75 IPWA KBAR N TO LAM PI 11/75
M 1914. 10. HEMINGWA 75 DPWA 0 K- P TO KBAR N 11/75
M 1920. 15. 20. VANHORN 75 DPWA 0 K- P TO LAM PIO 11/75
M (1915.) BELLEFON 76 IPWA 0 K- P TO LAM PI 2/77
M 3 1900. 4. CORDEN 76 DPWA - K- N TO PI- LAM 2/77
M 3 PREFERRED SOLUTION 3, SEE CORDEN 76 FOR OTHER POSSIBLILITES. 2/77
M 3 CORDEN 76 INCLUDES THE DATA OF COX 70 AS A SUBSAMPLE
M 1 1894. 5. CORDEN1 77 - K- N TO PI SIG 11/77
M 2 1909. 5. CORDEN1 77 - K- N TO PI SIG 11/77
M 1 THE 2 ENTRIES FOR CORDEN177 ARE FROM 2 DIFFERENT ACCEPTABLE SLTNS. 11/77
M NOT SEEN DECLAIS 77 DPWA KBAR N TO KBAR N 1/78
M 4 1925. OR 1933. MARTIN 77 DPWA KBAR N MULTICHNL 11/77
M 4 THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M 4 PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M 1920. 10. RLIC 77 DPWA KBAR N MULTICHNL 1/76
M 1937. 20. ALSTON 78 DPWA KBAR N ELASTIC 1/78
M N ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED 1/71
M . . . .
M AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

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46 Y*1(1915) WIDTH (MEV)

W A (50.0) (20.0) ARMENTER1 67 DPWA 0 ELASTIC, CH EXCH 11/67
W 52.0 25.0 SMART 68 DPWA -0 K-N TO LAMBDA PI 7/68
W 60.0 20.0 BERTHON 70 DPWA 0 K-P TO LAMBDA PI 7/70
W 75.0 20.0 BERTHON1 70 DPWA 0 K-P TO SIGMA PI 10/70
W 135.0 12.0 BRICMAN1 70 DPWA SIGTOT,ELAS,CHEX 1/71
W 77.0 27.0 COX 70 DPWA - K-N TO LAMBDA PI 6/70
W 70.0 20.0 GALTIERI 70 DPWA 0 K-P TO LAMBDA PI 7/70
W 70.0 15.0 LITCHFIEL 70 DPWA -0 K-N TO LAMBDA PI 6/70
W 70. 15. LITCHFIE 71 DPWA K-P TO KBAR N 10/71
W 146.0 22.0 KANE 72 DPWA 0 K-P TO PI SIG 10/71
W 70. 20. BAILLON 75 IPWA KBAR N TC LAM PI 11/75
W 85. 15. HEMINGWA 75 DPWA 0 K- P TO KBAR N 11/75
W 102. 18. VANHORN 75 DPWA 0 K- P TO LAM PIO 11/75
W (60.) BELLEFON 76 IPWA 0 K- P TO LAM PI 2/77
W 3 75. 14. CORDEN 76 DPWA - K- N TO PI- LAM 2/77
W 1 107. 14. CORDEN1 77 - K- N TO PI SIG 11/77
W 2 85. 13. CORDEN1 77 - K- N TO PI SIG 11/77
W 4 171. OR 173. MARTIN 77 DPWA KBAR N MULTICHNL 11/77
W 130. 10. RLIC 77 DPWA KBAR N MULTICHNL 1/76
W 161. 20. ALSTON 78 DPWA KBAR N ELASTIC 1/78
W A LACK OF DATA PREVENTS FROM DETERMINING UNAMB. THIS AMPLITUDE 11/67
W . . . .
W AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

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46 Y*1(1915) PARTIAL DECAY MODES

DECAY MASSES
P1 Y*1(1915) INTO KBAR N 497+ 939
P2 Y*1(1915) INTO LAMBDA PI 1115+ 139
P3 Y*1(1915) INTO SIGMA PI 1197+ 139
P4 Y*1(1915) INTO Y*1(1385) PI P-WAVE 139+1384
P5 Y*1(1915) INTO Y*1(1385) PI F-WAVE 139+1384

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46 Y*1(1915) BRANCHING RATIOS

R1 Y*1(1915) INTO (KBAR N)/TOTAL (P1)
R1 A (0.12) (.01) ARMENTER1 67 DPWA 0 ELASTIC, CH EXCH 11/67
R1 0.18 (0.02) BRICMAN1 70 DPWA SIGTOT,ELAS,CHEX 1/71
R1 0.11 (0.03) CONFORTO 71 DPWA 0 ELASTIC, CH EXCH 6/70
R1 0.15 (0.04) LITCHFIE 71 DPWA K-P TO KBAR N 10/71
R1 .11 (.04) HEMINGWA 75 DPWA 0 K- P TO KBAR N 11/75
R1 4 (.08)OR .08 MARTIN 77 DPWA KBAR N MULTICHNL 11/77
R1 .05 (.03) RLIC 77 DPWA KBAR N MULTICHNL 1/76
R1 .14 (.05) ALSTON 78 DPWA KBAR N ELASTIC 1/78

R2 Y*1(1915) FROM KBAR N INTO LAMBDA PI SQRT(P1*P2)
R2 -0.08 (0.02) SMART 68 DPWA -0 K-N TO LAMBDA PI 7/68
R2 -0.1 (0.02) BERTHON 70 DPWA 0 K-P TO LAMBDA PI 7/70
R2 -0.09 (0.02) COX 70 DPWA - K-N TO LAMBDA PI 6/70
R2 -0.11 (0.03) GALTIERI 70 DPWA 0 K-P TO LAMBDA PI 7/70
R2 -0.07 (0.015) LITCHFIEL 70 DPWA -0 K-N TO LAMBDA PI 6/70
R2 -.087 (.056) DEVENISH 74 0 FIXED T DISP REL 4/75
R2 -.06 (.02) BAILLON 75 IPWA KBAR N TO LAM PI 11/75
R2 -.09 (.02) VANHORN 75 DPWA 0 K- P TO LAM PIO 11/75
R2 (-.10) BELLEFON 76 IPWA 0 K- P TO LAM PI 2/77
R2 3 -.10 .01 CORDEN 76 DPWA - K- N TO PI- LAM 2/77
R2 4 (-.09)OR -.09 MARTIN 77 DPWA KBAR N MULTICHNL 11/77
R2 -.09 (.03) RLIC 77 DPWA KBAR N MULTICHNL 1/76

R3 Y*1(1915) FROM KBAR N INTO SIGMA PI SQRT(P1*P3)
R3 A (0.00) (0.01) ARMENTERO 67 DPWA 0 K-P TO SIGMA PI 11/67
R3 -0.13 (0.03) BERTHON1 70 DPWA 0 K-P TO SIGMA PI 10/70
R3 -0.06 (0.03) GALTIERI 70 DPWA 0 K-P TO SIGMA PI 7/70
R3 -0.137 (0.015) KANE 72 DPWA 0 K-P TO PI SIG 10/71
R3 1 -.17 .01 CORDEN1 77 - K- N TO PI SIG 11/77
R3 2 -.15 .02 CORDEN1 77 - K- N TO PI SIG 11/77
R3 4 (-.05)OR -.05 MARTIN 77 DPWA KBAR N MULTICHNL 11/77
R3 -.19 (.03) RLIC 77 DPWA KBAR N MULTICHNL 1/76
R3 . . . .
R3 AVG MOD 0.1660 0.0089 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3 STUDENT 0.1661 0.0099 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

Baryons
Σ(1915), Σ(1940)

Data Card Listings
For notation, see key at front of Listings.

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R4      Y*1(1915) FROM KBAR N INTO Y*1(1385) PI P-WAVE    SQRT(P1*P4)
R4           LESS THAN .01                  CAMERON    78 DPWA  0 K-P TO S(1385)PI  1/78

R5      Y*1(1915) FROM KBAR N INTO Y*1(1385) PI F-WAVE    SQRT(P1*P5)
R5    5          +.039       .009           CAMERON    78 DPWA  0 K-P TO S(1385)PI  1/78
R5    5   THE SIGN IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST                12/79*
R5    5   CONVENTION.                                                              12/79*

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REFERENCES FOR Y*1(1915)


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ARMENTER 67 PL 24B 198          ARMENTEROS,FERRO-LUZZI+  (CERN,HEID,SACLAY)
ARMENTE1 67 NP B3 592           ARMENTEROS,FERRO-LUZZI+  (CERN,HEID, SACLAY)
SMART    68 PR 169 1330         W M SMART                             (LRL)IJP

BERTHON  70 NP B20 476          +RANGAN, VRANA, +(COL FRANCE, RHEL, SACLAY)IJP
BERTHON1 70 NP B24 417          +VRANA, BUTTERWORTH, + (CDEF, RHEL, SACLAY)IJ
BRICMAN1 70 PL 33B 511          +FERRO-LUZZI,LAGNAUX                    (CERN)
COX      70 NP B19 61           +ISLAM, COLLEY, +     (BIRM,EDIN,GLAS,LOIC)IJP
GALTIERI 70 DUKE CONF 173       A BARBARO-GALTIERI                    (LRL)IJP
LITCHFIE 70 NP B22 269          P J LITCHFIELD                  (RUTHERFORD)IJP

CONFORTO 71 NP  B34  41         +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
LITCHFIE 71 NP  B30 125         LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
KANE     72 PR D5 1583          D F KANE                              (LBL)IJP
DEVENISH 74 NP B81 330          DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LCUC)

BAILLON  75 NP B94 39           P. BAILLON,P. J. LITCHFIELD      (CERN,RHEL)IJP
HEMINGWA 75 NP B91 12           HEMINGWAY, EADES, HARMSEN+   (CERN,HEID,MPIM)IJP
VANHORN  75 NP B87 145          A. J. VAN HORN                        (LBL)IJP
    ALSO 75 NP B87 157          A. J. VAN HORN                        (LBL)IJP

BELLEFON 76 NP B109 129         DE BELLEFON,BERTHON                   (CDEF)IJP
CORDEN   76 NP B104 382         +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP

CORDEN1  77 NP B125 61          +COX,KENYON,ONEALE,STUBBS,SUMOROK+    (BIRM)IJP
DECLAIS  77  CERN 77-16         +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP
MARTIN   77 NP B127 349         MARTIN,PIDCOCK,MOORHOUSE         (LOUC+GLAS)IJP
    ALSO 77 NP B126 266         MARTIN,PIDCOCK                        (LOUC)
    ALSO 77 NP B126 285         MARTIN,PIDCOCK                        (LOUC)IJP
RLIC     77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182          +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007         ALSTON-GARNJOST,KENNEY       (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189         +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS

SMART    66 PRL 17 556          W M SMART,A KERNAN,G E KALMUS,R P ELY (LRL)IJP
    SUPERSEDED BY SMART 68.
CONFORTO 68 NP B8 265           +HARMSEN, LASINSKI, +     (CHICAGO, HEIDEL)
    SUPERSEDED BY CONFORTO 71.

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1915 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

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                 29  Y*1(1915, JP=    ) I=1         PRODUCTION EXPERIMENTS

                 SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

                 SEE THE NOTES TO THE Y*1(1915) AND Y*1(1940), WHICH
                 IMMEDIATELY PRECEDE AND FOLLOW THIS ENTRY.  HERE WE
                 LIST ONLY PARAMETERS OF PEAKS SEEN IN CROSS SECTIONS
    AND INVARIANT-MASS DISTRIBUTIONS.  THE CROSS-SECTION PEAKS ARE ALMOST
    CERTAINLY ASSOCIATED WITH THE F15 Y*1(1915) SEEN IN PARTIAL-WAVE
    ANALYSES.  THE INVARIANT-MASS PEAKS SEEM MORE LIKELY TO BE ASSOCIATED
    WITH THE D13 Y*(1940).

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                 29  Y*1(1915) MASS (MEV) (PROD. EXP.)

M         CROSS-SECTION PEAKS --
M           1905.0      5.0             BUGG       68 CNTR    K-P, D TOTAL      11/66
M           1906.0      6.0             BRICMAN    70 CNTR  0 TOTAL AND CH EX    6/70
M           1912.0     10.0             COOL       70 CNTR    K-P, D TOTAL      10/70
M         INVARIANT-MASS-DISTRIBUTION PEAKS --
M          (1942.0)    (9.0)            BOCK       65 HBC     PBAR P 5.7 BEV/C
M           1940.0     11.0             AGUILAR    70 HBC   + 3.9-4.6 GEV/C K-   5/70
M         ELASTIC DCS --                                                         2/73
M    1      1931.      9.               DADO       72 HBC   0 K-P ELSTC DCS    . 2/73
M    1  G7 INDICATED BY LEGENDRE COEFFS.,G9 NOT RULED OUT.                       2/73
M      42 1979.       14.               BRIEFEL    77 HBC   + XI K MODE 2.9K-P   1/78
M           . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.7)

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                 29  Y*1(1915) WIDTH (MEV) (PROD. EXP.)

W         CROSS-SECTION PEAKS --
W            60.0      10.0             BUGG       68 CNTR                      11/66
W            50.0      12.0             BRICMAN    70 CNTR  0 TOTAL AND CH EX    6/70
W           (30.0)                      COOL       70 CNTR    K-P, D TOTAL      10/70
W         INVARIANT-MASS-DISTRIBUTION PEAKS --
W           (36.0)    (20.0)   (36.0)   BOCK       65 HBC
W            90.0      20.0             AGUILAR    70 HBC   + 3.9-4.6 GEV/C K-   5/70
W         ELASTIC DCS --                                                         2/73
W    1       70.       14.              DADO       72 HBC   0 K-P ELSTC DCS      2/73
W      42    69.       32.              BRIEFEL    77 HBC   + XI K MODE 2.9K-P   1/78
W           . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                 29  Y*1(1915) PARTIAL DECAY MODES (PROD. EXP.)

                                                              DECAY MASSES
P1      Y*1(1915) INTO KBAR N                                497+ 939
P2      Y*1(1915) INTO LAMBDA PI                            1115+ 134
P3      Y*1(1915) INTO SIGMA PI                             1197+ 139
P4      Y*1(1915) INTO XI K                                 1314+ 493

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                 29  Y*1(1915) BRANCHING RATIOS (PROD. EXP.)

R1      Y*1(1915) INTO (KBAR N)/TOTAL                           (P1)
R1          THESE VALUES OF ELASTICITIES ASSUME J=5/2 --
R1             0.06                     BUGG       68 CNTR    ASSUMING J=5/2     6/68
R1             0.07        0.02         BRICMAN    70 CNTR  0 TOTAL AND CH EX    6/70
R1             0.07                     COOL       70 CNTR    K-P, D TOTAL      10/70
R1    1  THIS ELASTICITY ASSUMES J=7/2                                           2/73
R1    1         .62         .08         DADO       72 HBC   0 K-P ELSTC DCS      2/73
R1            . . . . . . . . . .
R1   AVG       0.10        0.13     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 6.7)
R1   STUDENT   0.077       0.022    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R2      Y*1(1915) INTO (KBAR N)/(SIGMA PI)                      (P1)/(P3)
R2             (.37) OR LESS            BARNES     69 HBC   + 1 STAN. DEV.      10/69

R3      Y*1(1915) INTO (LAMBDA PI)/(SIGMA PI)                   (P2)/(P3)
R3             (.28) OR LESS            BARNES     69 HBC   + 1 STAN. DEV.      10/69

R4      Y*1(1915) INTO (XI K)                                   (P4)
R4       42    SEEN                     BRIEFEL    77 HBC   + K-P 2.87 GEV       1/78

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REFERENCES FOR Y*1(1915) (PROD. EXP.)


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BOCK     65 PL 17 166           +COOPER,FRENCH,KINSON, +         (CERN,SACLAY) I
COOL     66 PRL 16 1228         +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
    SUPERSEDED BY COOL 70.
BUGG     68 PR 168 1466         +GILMORE,KNIGHT,DAVIES+      (BIRM,CAVE,RHEL)I
BARNES   69 PRL 22 479          +FLAMINIO,MONTANET,SAMIOS +         (BNL+SYRA)

AGUILAR  70 PRL 25 58           AGUILAR-BENITEZ, BARNES, +          (BNL,SYRA)
BRICMAN  70 PL 31B 152          +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
COOL     70 PR D1 1887          +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
DADO     72 PRL 29 1695         +BIRMAN,GOLDBERG,WEISS                 (HAIF)JP
BRIEFEL  77 PRD 16 2706         +GOUREVITCH,CHANG+      (BRAN+UMD+SYRA+TUFT)

                                PAPERS NOT REFERRED TO IN DATA CARDS

PRIMER   68 PRL 20 610          +GOLDBERG,JAEGER,BARNES,DORNAN + (SYRA,BNL)
    SUPERSEDED BY BARNES 69 AND AGUILAR-BENITEZ 70.

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Σ(1940) D'''_{13}

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                 98  Y*1(1940, JP=3/2-) I=1

                 SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

                 SUCH A RESONANCE IS SUGGESTED BY SOME BUT NOT ALL
                 PARTIAL-WAVE ANALYSES IN THIS REGION.  THIS
                 EFFECT IS PERHAPS ASSOCIATED WITH THE BUMPS SEEN
                 IN PRODUCTION EXPERIMENTS NEAR THIS MASS.  SEE
                 THE PRECEDING ENTRY.

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                 98  Y*1(1940) MASS (MEV)

M          1940.0      50.0             GALTIERI  70 DPWA    K- N TO LAM PI     7/70
M          1940.0      40.0             GALTIERI  70 DPWA    K-P TO SIGMA PI    7/70
M          1940.0      30.0             LITCHFIEL 70 DPWA    K- N TO LAM PI     7/70
M          1985.0      (5.0)            KANE      72 DPWA  0 K-P TO PI SIG     10/71
M    2    (1865.)                       LEA       73 DPWA    MULTICHNL K-MTRX   9/73
M    2  ONLY UNCONSTRAINED STATES FROM TABLE 1 OF LEA73 ARE IN LISTINGS.          9/73
M          1940.       20.              LITCHFI2  74 DPWA  0 K-P TO L(1520)PI  10/74
M          1950.       20.              LITCHFI3  74 DPWA  0 K-P TO KBAR DEL   10/74
M          1950.       30.              BAILLON   75 IPWA    KBAR N TO LAM PI  11/75
M          1949.       40.       60.    VANHORN   75 DPWA  0 K- P TO LAM PIO   11/75
M    4    (1940.)                       BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77
M    4  SLIGHT BUMP IN MODULUS OF F7 WAVE.                                      2/77
M    5     1886. OR 1893.               MARTIN    77 DPWA    KBAR N MULTICHNL  11/77
M    5  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    5  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1920.       50.              RLIC      77 DPWA    KBAR N MULTICHNL   1/76
M            . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                 98  Y*1(1940) WIDTH (MEV)

W           200.0      50.0             GALTIERI  70 DPWA    K- N TO LAM PI     7/70
W           200.0      50.0             GALTIERI  70 DPWA    K-P TO SIGMA PI    7/70
W           280.0      40.0             LITCHFIEL 70 DPWA    K- N TO LAM PI     7/70
W           208.0     (22.0)            KANE      72 DPWA  0 K-P TO PI SIG     10/71
W    2     (108.9)                      LEA       73 DPWA    MULTICHNL K-MTRX   9/73
W            60.       20.              LITCHFI2  74 DPWA  0 K-P TO L(1520)PI  10/74
W            70.       30.       20.    LITCHFI3  74 DPWA  0 K-P TO KBAR DEL   10/74
W           150.       75.              BAILLON   75 IPWA    KBAR N TO LAM PI  11/75
W           160.       70.       40.    VANHORN   75 DPWA  0 K- P TO LAM PIO   11/75
W    5      157. OR 159.                MARTIN    77 DPWA    KBAR N MULTICHNL  11/77
W           300.       80.              RLIC      77 DPWA    KBAR N MULTICHNL   1/76
W           170.0      25.0             CAMERON2  78 DPWA    K-P TO K*(890) N 12/79*
W            . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)

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                 98  Y*1(1940) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      Y*1(1940) INTO KBAR N                                497+ 939
P2      Y*1(1940) INTO LAMBDA PI                            1115+ 139
P3      Y*1(1940) INTO SIGMA PI                             1197+ 139
P4      Y*1(1940) INTO Y*0(1520) PI P-WAVE                   134+1518
P5      Y*1(1940) INTO Y*0(1520) PI F-WAVE                   134+1518
P6      Y*1(1940) INTO KBAR DELTA(1232) S-WAVE               493+1232
P7      Y*1(1940) INTO KBAR DELTA(1232) D-WAVE               493+1232
P8      Y*1(1940) INTO Y*1(1385) PI S-WAVE                   139+1384
P9      Y*1(1940) INTO N K*(890), S3 WAVE                    939+ 892

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Data Card Listings

For notation, see key at front of Listings.

Baryons

Σ(1940), Σ(2000), Σ(2030)

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                    98  Y*1(1940) BRANCHING RATIOS

R1      Y*1(1940) FROM KBAR N INTO LAMBDA PI                 SQRT(P1*P2)
R1           -0.12        0.04             GALTIERI  70 DPWA    K- N TO LAM PI     7/70
R1           -0.14        0.03             LITCHFIEL 70 DPWA    K- N TO LAM PI     7/70
R1    2      (-.11)                        LEA       73 DPWA    MULTICHNL K-MTRX   9/73
R1           -.153        .070             DEVENISH  74       0 FIXED T DISP REL   4/75
R1           -.04         .02              BAILLON   75 IPWA    KBAR N TO LAM PI  11/75
R1           -.05         .03       .02    VANHORN   75 DPWA  0 K-P TO LAM PIO    11/75
R1    5      (-.15)OR -.14                 MARTIN    77 DPWA    KBAR N MULTICHNL  11/77
R1           -.06         .03              RLIC      77 DPWA    KBAR N MULTICHNL   1/76
R1          . . . . . . . . . .
R1    AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

R2      Y*1(1940) FROM KBAR N INTO SIGMA PI                  SQRT(P1*P3)
R2           -0.12        0.03             GALTIERI  70 DPWA    K-P TO SIGMA PI    7/70
R2           -0.093       (0.006)          KANE      72 DPWA  0 K-P TO PI SIG     10/71
R2    2      NOT SEEN                      LEA       73 DPWA    MULTICHNL K-MTRX   9/73
R2    5      (+.16)OR +.16                 MARTIN    77 DPWA    KBAR N MULTICHNL  11/77
R2           -.08         .04              RLIC      77 DPWA    KBAR N MULTICHNL   1/76
R2          . . . . . . . . . .
R2    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R3      Y*1(1940) INTO KBAR N                                (P1)                  9/73
R3    2      (.21)                         LEA       73 DPWA    MULTICHNL K-MTRX   9/73
R3    5      (.14)OR .13                   MARTIN    77 DPWA    KBAR N MULTICHNL  11/77
R3           LESS THAN .04                 RLIC      77 DPWA    KBAR N MULTICHNL   1/76
R3     NO SIGNAL FOR THIS STATE WITH X LARGER THAN ABOUT .03 IN THE               11/75
R3     ANALYSIS OF HEMINGWAY 75.                                                  11/75

R4      Y*1(1940) FROM KBAR N TO Y*0(1520) PI P-WAVE         SQRT(P1*P4)
R4    1      -.11         .04              LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
R4    1  ASSUMES LAMBDA(1520) ELASTICITY=.45,SIGN RLTV. TO SIG(2030) DECAY.       10/74
R4    6     LESS THAN .03                  CAMERON   77 DPWA  0 K-P TO L(1520)PI  1/78
R4    6  ASSUMES LAMBDA(1520) ELASTICITY=.46.                                      1/78

R5      Y*1(1940) FROM KBAR N TO Y*0(1520) PI F-WAVE         SQRT(P1*P5)
R5    1      -.08         .04              LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
R5    1  ASSUMES LAMBDA(1520) ELASTICITY=.45,SIGN RLTV. TO SIG(2030) DECAY.       10/74
R5    6       .062        .021             CAMERON   77 DPWA  0 K-P TO L(1520)PI  1/78
R5    6  ASSUMES LAMBDA(1520) ELASTICITY=.46.                                      1/78
R5          . . . . . . . . . .
R5    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R6      Y*1(1940) FROM KBAR N TO KBAR DELTA(1232) S-WAVE SQRT(P1*P6)
R6    3      -.16         .05              LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74
R6    3  SIGN RELATIVE TO SIGMA(2030) DECAY                                       10/74

R7      Y*1(1940) FROM KBAR N TO KBAR DELTA(1232) D-WAVE SQRT(P1*P7)
R7    3      -.14         .05              LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74
R7    3  SIGN RELATIVE TO SIGMA(2030) DECAY                                       10/74

R8      Y*1(1940) FROM KBAR N TO Y*1(1385) PI S-WAVE         SQRT(P1*P8)
R8    7      +.066        .025             CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R8    7  THE SIGN IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST               12/79*
R8    7  CONVENTION.                                                             12/79*

R9      Y*1(1940) FROM KBAR N INTO N K*(890), S3 WAVE        SQRT(P1*P9)
R9    8      -0.09        0.02             CAMERON2  78 DPWA    K-P TO K*N       12/79*
R9    8  UPPER LIMITS ON THE D1 AND D3 WAVES ARE EACH 0.03.                      12/79*

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                         REFERENCES FOR Y*1(1940)

GALTIERI 70 DUKE CONF 173      A BARBARO-GALTIERI                        (LRL)IJP
LITCHFIE 70 NP B22 269         P J LITCHFIELD                     (RUTHERFORD)IJP
KANE     72 PR D5 1583         D F KANE                                  (LBL)IJP
LEA      73 NP B56 77          +MARTIN,MOORHOUSE+  (RHEL+LOUC+GLAS+AARHUS)IJP

DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LCUC)
LITCHFI2 74 NP B74 19          LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP
LITCHFI3 74 NP B74 39          LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP

BAILLON  75 NP B94 39          P. BAILLON,P. J. LITCHFIELD      (CERN,RHEL)IJP
VANHORN  75 NP B87 145         A. J. VAN HORN                            (LBL)IJP
    ALSO 75 NP B87 157         A. J. VAN HORN                            (LBL)IJP

BELLEFON 76 NP B109 129        DE BELLEFON,BERTHON                      (CDEF)IJP
CAMERON  77 NP B131 399        +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266        MARTIN,PIDCOCK                           (LCUC)
    ALSO 77 NP B126 285        MARTIN,PIDCOCK                           (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
CAMERON  78 NP B143 189        +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327        +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP

                         PAPERS NOT REFERRED TO IN DATA CARDS

HEMINGWA 75 NP B91 12          HEMINGWAY,EADES,HARMSEN+      (CERN,HEID,MPIM)IJP

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Σ(2000)

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                02  Y*1(2000, JP=1/2-) I=1
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S''_{11}

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WE LIST HERE ALL REPORTED S11 STATES LYING ABOVE
THE Y*1(1750)

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                    02  Y*1(2000) MASS (MEV)

M            2004.        40.              VANHORN   75 DPWA  0 K-P TO LAM PIO    11/75
M     1      1755. OR 1834.                MARTIN    77 DPWA    KBAR N MULTICHNL  11/77
M     1  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     1  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M            1955.        15.              RLIC      77 DPWA    KBAR N MULTICHNL   1/76

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                    02  Y*1(2000) WIDTH (MEV)

W            116.         40.              VANHORN   75 DPWA  0 K-P TO LAM PIO    11/75
W     1      413. OR 450.                  MARTIN    77 DPWA    KBAR N MULTICHNL  11/77
W            170.         40.              RLIC      77 DPWA    KBAR N MULTICHNL   1/76

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                    02  Y*1(2000) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      Y*1(2000) INTO KBAR N                                  497+ 939
P2      Y*1(2000) INTO LAMBDA PI                              1115+ 134
P3      Y*1(2000) INTO SIGMA PI                               1197+ 139
P4      Y*1(2000) INTO LAMBDA(1520) PI                         139+1518
P5      Y*1(2000) INTO N K*(890), S1 WAVE                      939+ 892
P6      Y*1(2000) INTO N K*(890), D3 WAVE                      939+ 892

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                    02  Y*1(2000) BRANCHING RATIOS

R1      Y*1(2000) FROM KBAR N INTO LAMBDA PI                 SQRT(P1*P2)
R1         NOT SEEN                        BAILLON   75 IPWA    KBAR N TO LAM PI  11/75
R1           +.07         .02       .01    VANHORN   75 DPWA  0 K-P TO LAM PIO    11/75
R1    1      (-.19)OR -.18                 MARTIN    77 DPWA    KBAR N MULTICHNL  11/77
R1            .08         .03              RLIC      77 DPWA    KBAR N MULTICHNL   1/76

R2      Y*1(2000) INTO (KBAR N)/TOTAL                        (P1)                  1/76
R2    1      (.62)OR .57                   MARTIN    77 DPWA    KBAR N MULTICHNL  11/77
R2            .44         .05              RLIC      77 DPWA    KBAR N MULTICHNL   1/76

R3      Y*1(2000) FROM KBAR N INTO SIGMA PI                  SQRT(P1*P3)           1/76
R3    1      (+.26)OR +.24                 MARTIN    77 DPWA    KBAR N MULTICHNL  11/77
R3           +.20         .04              RLIC      77 DPWA    KBAR N MULTICHNL   1/76

R4      Y*1(2000) FROM KBAR N TO LAMBDA(1520) PI             SQRT(P1*P4)
R4    2      +0.081       .021             CAMERON   77 DPWA  0 P-WAVE DECAY       1/78
R4    2  ASSUMES LAMBDA(1520) ELASTICITY=0.46.  THE SIGN IS CHANGED HERE TO      12/79*
R4    2  BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.                          12/79*

R5      Y*1(2000) FROM KBAR N INTO N K*(890), S1 WAVE        SQRT(P1*P5)
R5    3      +0.10        0.02             CAMERON2  78 DPWA    K-P TO K*N       12/79*
R5    3  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST          12/79*
R5    3  CCNVENTION.                                                             12/79*

R6      Y*1(2000) FRCM KBAR N INTO N K*(890), D3 WAVE        SQRT(P1*P6)
R6           -0.07        0.03             CAMERON2  78 DPWA    K-P TO K*N       12/79*

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                         REFERENCES FOR Y*1(2000)

BAILLON  75 NP B94 39          P. BAILLON,P. J. LITCHFIELD      (CERN,RHEL)IJP
VANHORN  75 NP B87 145         A. J. VAN HORN                            (LBL)IJP
    ALSO 75 NP B87 157         A. J. VAN HORN                            (LBL)IJP

CAMERON  77 NP B131 399        +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266        MARTIN,PIDCOCK                           (LOUC)
    ALSO 77 NP B126 285        MARTIN,PIDCOCK                           (LCUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
CAMERON2 78 NP B146 327        +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP

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Σ(2030)

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                47  Y*1(2030, JP=7/2+) I=1
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F_{17}

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                SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

                THIS ENTRY ONLY INCLUDES RESULTS FROM PARTIAL-WAVE
                ANALYSES.  PARAMETERS OF PEAKS SEEN IN CROSS-SECTIONS
                AND INVARIANT-MASS DISTRIBUTIONS AROUND 2030 MEV ARE
      GIVEN IN THE NEXT ENTRY.  EVENTUALLY THE PARTIAL-WAVE ANALYSES SHOULD
      GIVE THE BEST RESULTS, AS THEY ISOLATE THE F17 WAVE.  THIS SUPERIORITY
      IS, HOWEVER, PROBABLY NOT YET ATTAINED, AND WE RELY ON BOTH ENTRIES
      FOR PARAMETERS GIVEN IN THE MAIN BARYON TABLE.

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                    47  Y*1(2030) MASS (MEV)

M          (2030.0)     (20.0)             WOHL      66 HBC   0 K-P TO LAM PIO     7/66
M           2032.0        6.0              SMART     68 DPWA -  K-N TO LAMBDA PI   6/68
M           2030.0       10.0              BERTHON   70 DPWA  0 K-P TO LAMBDA PI   7/70
M           2035.0       10.0              BERTHON1  70 DPWA  0 K-P TO SIGMA PI   10/70
M           2027.0        6.0              COX       70 DPWA -  K-N TO LAMBDA PI   6/70
M           2010.0       15.0              GALTIERI  70 DPWA  0 K-P TO LAMBDA PI   7/70
M           2000.0       20.0              GALTIERI  70 DPWA  0 K-P TO SIGMA PI    7/70
M           2022.0        4.0              LITCHFIEL 70 DPWA -0 K-N TO LAMBDA PI   6/70
M           2025.        15.               LITCHFIE  71 DPWA    K-P TO KBAR N     10/71
M           2034.0       14.0              KANE      72 DPWA  0 K-P TO PI SIG     10/71
M           2025.        10.               LITCHFI1  74 DPWA  0 K-P TO L(1815)PI 10/74
M           2035.        10.               LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
M           2020.        30.               LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74
M           2035.        15.               BAILLON   75 IPWA    KBAR N TO LAM PI  11/75
M           2038.        10.               HEMINGWA  75 DPWA  0 K- P TO KBAR N    11/75
M           2042.        11.               VANHORN   75 DPWA  0 K-P TO LAM PIO    11/75
M          (2030.)                         BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77
M     4     2030.         3.               CORDEN    76 DPWA  - K- N TO PI- LAM    2/77
M     4  PREFERRED SOLUTION 3, SEE CORDEN 76 FOR OTHER POSSIBLILITES.              2/77
M     4  CORDEN 76 INCLUDES THE DATA OF COX 70 AS A SUBSAMPLE.
M     C     2038.        10.               CORDEN2   77       - K- N TO K* N      11/77
M     6     2027. TO 2057.                 GOYAL     77 DPWA  - K- N TO SIG PI     1/78
M           2040.         5.               RLIC      77 DPWA    KBAR N MULTICHNL   1/76
M          . . . . . . . . . .
M     AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                    47  Y*1(2030) WIDTH (MEV)

W          (170.0)                         WOHL      66 HBC   0                    7/66
W           160.0        16.0              SMART     68 DPWA -  K-N TO LAMBDA PI   6/68
W           165.0        30.0       15.0   BERTHON   70 DPWA  0 K-P TO LAMBDA PI   7/70
W           150.0        20.0              BERTHON1  70 DPWA  0 K-P TO SIGMA PI   10/70
W           158.0        16.0              COX       70 DPWA -  K-N TO LAMBDA PI   6/70
W           115.0        15.0              GALTIERI  70 DPWA  0 K-P TO LAMBDA PI   7/70
W           100.0        40.0              GALTIERI  70 DPWA  0 K-P TO SIGMA PI    7/70
W           170.0        15.0              LITCHFIEL 70 DPWA -0 K-N TO LAMBDA PI   6/70
W           200.         30.               LITCHFIE  71 DPWA    K-P TO KBAR N     10/71
W           118.0        12.0              KANE      72 DPWA  0 K-P TO PI SIG     10/71
W            70. TO 125.                   LITCHFI1  74 DPWA  0 K-P TO L(1815)PI 10/74
W           160.         20.               LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
W           200.         30.               LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74
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Baryons
Σ(2030)

Data Card Listings
For notation, see key at front of Listings.

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W          180.      20.            BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W          172.      15.            HEMINGWA  75 DPWA  0 K- P TO KBAR N   11/75
W          178.      13.            VANHORN   75 DPWA  0 K-P TO LAM PIO   11/75
W         (160.)                    BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
W   4      201.       9.            CORDEN    76 DPWA  - K- N TO PI- LAM   2/77
W   C      137.      40.            CORDEN2   77       - K- N TO K* N     11/77
W         (260.)                    DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78
W   6      126. TO  195.            GOYAL     77 DPWA  - K- N TO SIG PI    1/78
W          190.      10.            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W         . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

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                 47  Y*1(2030) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1      Y*1(2030) INTO KBAR N                              497+ 939
P2      Y*1(2030) INTO LAMBDA PI                          1115+ 134
P3      Y*1(2030) INTO SIGMA PI                           1197+ 139
P4      Y*1(2030) INTO XI K                               1321+ 497
P5      Y*1(2030) INTO Y*0(1815) PI P-WAVE                 134+1820
P6      Y*1(2030) INTO Y*0(1520) PI D-WAVE                 134+1518
P7      Y*1(2030) INTO Y*0(1520) PI G-WAVE                 134+1518
P8      Y*1(2030) INTO KBAR DELTA(1232) F-WAVE             493+1232
P9      Y*1(2030) INTO KBAR DELTA(1232) H-WAVE             493+1232
P10     Y*1(2030) INTO Y*1(1385) PI F-WAVE                 139+1384
P11     Y*1(2030) INTO N K*(890), F1 WAVE                  939+ 892
P12     Y*1(2030) INTO N K*(890), F3 WAVE                  939+ 892

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                 47  Y*1(2030) BRANCHING RATIOS

R1      Y*1(2030) INTO (KBAR N)/TOTAL                     (P1)
R1          (0.25)                  WOHL      66 HBC   0 K-P CH EX         7/66
R1  D       (0.11)                  DAUM      68 CNTR    K-P ELA,POL,SIGT  7/70
R1           0.17      0.04         CAMPBELL  71 DBC   - K- NEUTRON ELAST  1/71
R1           0.18      0.02         LITCHFIE  71 DPWA    K-P TO KBAR N   .10/71
R1            .18       .03         HEMINGWA  75 DPWA  0 K- P TO KBAR N   11/75
R1          (.15)                   DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78
R1            .24       .02         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1  D   DAUM 68 ASSUMES (J+1/2)*P1 VALUE SEEN IN TOTAL CROSS SECTION.
R1         . . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

R2      Y*1(2030) FROM KBAR N INTO LAMBDA PI             SQRT(P1*P2)
R2          (0.20)                  WOHL      66 HBC   0 K-P TO LAMBDA PI  7/66
R2          +0.21      0.01         SMART     68 DPWA -  K-N TO LAMBDA PI  6/68
R2          +0.2       0.02         BERTHON   70 DPWA  0 K-P TO LAMBDA PI  7/70
R2          +0.19      0.01         COX       70 DPWA -  K-N TO LAMBDA PI  6/70
R2          +0.16      0.03         GALTIERI  70 DPWA  0 K-P TO LAMBDA PI  7/70
R2          +0.20      0.008        LITCHFIEL 70 DPWA -0 K-N TO LAMBDA PI  6/70
R2           +.195      .053        DEVENISH  74       0 FIXED T DISP REL  4/75
R2           +.18       .02         BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R2           +.20       .01         VANHORN   75 DPWA  0 K-P TO LAM PIO   11/75
R2          (.20)                   BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
R2   4       +.20       .01         CORDEN    76 DPWA  - K- N TO PI- LAM   2/77
R2           +.18       .02         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R2         . . . . . . . . . .
R2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R3      Y*1(2030) FROM KBAR N INTO SIGMA PI              SQRT(P1*P3)
R3  L      (-0.09)    (0.02)        BERTHON1  70 DPWA  0 K-P TO SIGMA PI  10/70
R3         -0.052      0.010        GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
R3         -0.10       0.03         LITCHFIE  71 DPWA    K-P TO SIG PI     3/72
R3  L   LITCHFIELD 71 IS AN UPDATE OF BERTHON1 70                          3/72
R3         -0.086      0.014        KANE      72 DPWA  0 K-P TO PI SIG    10/71
R3   A      -.09        .01         CORDEN1   77       - K- N TO PI SIG   11/77
R3   B      -.06        .01         CORDEN1   77       - K- N TO PI SIG   11/77
R3   A  THE 2 ENTRIES FOR CORDEN177 ARE FROM 2 DIFFERENT ACCEPTABLE SLTNS. 11/77
R3  6      (-.085)    (.02)         GOYAL     77 DPWA  - K- N TO SIG PI    1/78
R3  6   THIS COUPLING IS EXTRACTED FROM UNNORMALIZED DATA.                  1/78
R3          -.15        .03         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R3         . . . . . . . . . .
R3  AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

R4      Y*1(2030) FROM KBAR N INTO XI K                  SQRT(P1*P4)
R4          (0.05) OR LESS          TRIPP     67 RVUE  0 K-P TO XI K       8/67
R4          (0.05) OR LESS          BURGUN    68 DPWA  0 K-P TO XI K      10/69
R4          (0.023)                 MULLER    69 DPWA  0                   7/70

R5      Y*1(2030) FROM KBAR N TO Y*0(1815)  PI P-WAVE    SQRT(P1*P5)
R5   1        .18       .04         LITCHFI1  74 DPWA  0 K-P TO L(1815)PI 10/74
R5   1  ASSUMES LAMBDA(1815) ELASTICITY=.6                                10/74
R5            .14       .02         CORDEN2   75 DBC   - KBAR PI- NUCLEON 11/75
R5         . . . . . . . . . .
R5  AVG       0.148     0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  STUDENT   0.148     0.020   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R6      Y*1(2030) FROM KBAR N TO Y*0(1520) PI D-WAVE     SQRT(P1*P6)
R6   2        .14       .03         LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
R6   2  ASSUMES LAMBDA(1520) ELASTICITY=.45                               10/74
R6  3       (.10)      (.03)        CORDEN2   75 DBC   - KBAR PI- NUCLEON 11/75
R6  3   UPPER LIMIT                                                        11/75
R6   5      +0.114      .010        CAMERON   77 DPWA  0 K-P TO L(1520)PI  1/78
R6   5  ASSUMES LAMBDA(1520) ELASTICITY=.46.  THE SIGN IS CHANGED HERE TO  12/79*
R6   5  BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.                     12/79*
R6         . . . . . . . . . .
R6  AVG       0.1166    0.0095  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6  STUDENT   0.116     0.010   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R7      Y*1(2030) FROM KBAR N TO Y*0(1520) PI G-WAVE     SQRT(P1*P7)
R7   2        .02       .02         LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
R7   2  ASSUMES LAMBDA(1520) ELASTICITY=.45                               10/74
R7   5      +0.146      .010        CAMERON   77 DPWA  0 K-P TO L(1520)PI  1/78
R7   5  ASSUMES LAMBDA(1520) ELASTICITY=.46.  THE SIGN IS CHANGED HERE TO  12/79*
R7   5  BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.                     12/79*
R7         . . . . . . . . . .
R7  AVG       0.121     0.050   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 5.6)
R7  STUDENT   0.138     0.012   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R8      Y*1(2030) FROM KBAR N TO KBAR DELTA(1232) F-WAVE SQRT(P1*P8)
R8            .16       .03         LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74
R8  3       (.17)      (.03)        CORDEN2   75 DBC   - KBAR PI- NUCLEON 11/75
R8  3   UPPER LIMIT                                                        11/75

R9      Y*1(2030) FROM KBAR N TO KBAR DELTA(1232) H-WAVE SQRT(P1*P9)
R9            .00       .02         LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74

R10     Y*1(2030) FROM KBAR N TO Y*1(1385) PI F-WAVE     SQRT(P1*P10)
R10  7      +.153       .026        CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R10  7  THE SIGN IS CHANGED HERE TO BE IN ACCORD WITH THE BARYON-FIRST     12/79*
R10  7  CONVENTION.                                                        12/79*

R11     Y*1(2030) FROM KBAR N INTO N K*(890), F1 WAVE    SQRT(P1*P11)
R11         -0.02      0.01         CORDEN2   77         K-D TO K*N        12/79*
R11  8      +0.06      0.03         CAMERON2  78 DPWA    K-P TO K*N        12/79*
R11  8  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST     12/79*
R11  8  CONVENTION.                                                        12/79*
R11        . . . . . . . . . .
R11 AVG MOD   0.024     0.012   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R11 STUDENT   0.024     0.011   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R12     Y*1(2030) FROM KBAR N INTO N K*(890), F3 WAVE    SQRT(P1*P12)
R12         -0.12      0.02         CORDEN2   77         K-D TO K*N        12/79*
R12  9      +0.04      0.03         CAMERON2  78 DPWA    K-P TO K*N        12/79*
R12  9  THE UPPER LIMIT ON THE G3 WAVE IS 0.03.                            12/79*
R12        . . . . . . . . . .
R12 AVG MOD   0.095     0.037   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
R12 STUDENT   0.098     0.022   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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REFERENCES FOR Y*1(2030)


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WOHL     66 PRL 17 107         C G WOHL, F T SOLMITZ, M L STEVENSON  (LRL)IJP
TRIPP    67 NP B3 10           + LEITH, +     (LRL,SLAC,CERN,HEIDEL,SACLAY)
BURGUN   68 NP B8 447          +MEYER,PAULI,TALLINI +      (SACL+CDEF+RHEL)
DAUM     68 NP B7 19           +ERNE,LAGNAUX,SENS,STEUER,UDO          (CERN)JP
   CONFIRMS THE SPIN-PARITY ASSIGNMENT.
SMART    68 PR 169 1336        W M SMART                              (LRL)IJP
MULLER   69 THESIS,UCRL 19372 R A MULLER                              (LRL)

BERTHON  70 NP B20 476         +RANGAN, VRANA, +(COL FRANCE, RHEL, SACLAY)IJP
BERTHON1 70 NP B24 417         +VRANA, BUTTERWORTH, + (CDEF, RHEL, SACLAY)IJP
COX      70 NP B19 61          +ISLAM, COLLEY, +      (BIRM,EDIN,GLAS,LOIC)IJP
GALTIERI 70 DUKE CONF 173      A BARBARO-GALTIERI                     (LRL)IJP
LITCHFIE 70 NP B22 269         P J LITCHFIELD                   (RUTHERFORD)IJP

CAMPBELL 71 NP B25 75          +MORTON, NEGUS, GOYAL, MILLER  (GLAS, LOIC)IJP
LITCHFIE 71 NP  B30 125        LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
KANE     72 PR D5 1583         D F KANE                               (LBL)IJP

DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LCUC)
LITCHFI1 74 NP B74 12          LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP
LITCHFI2 74 NP B74 19          LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP
LITCHFI3 74 NP B74 39          LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP

BAILLON  75 NP B94 39          P. BAILLON,P. J. LITCHFIELD      (CERN,RHEL)IJP
CORDEN2  75 NP B92 365         +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP
HEMINGWA 75 NP B91 12          HEMINGWAY, EADES, HARMSEN+   (CERN,HEID,MPIM)IJP
VANHORN  75 NP B87 145         A. J. VAN HORN                         (LBL)IJP
   ALSO  75 NP B87 157         A. J. VAN HORN                         (LBL)IJP
BELLEFON 76 NP B109 129        DE BELLEFON,BERTHON                   (CDEF)IJP
CORDEN   76 NP B104 382        +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP

CAMERON  77 NP B131 399        +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
CORDEN1  77 NP B125 61         +COX,KENYON,ONEALE,STUBBS,SUMOROK+    (BIRM)IJP
CORDEN2  77 NP B121 365        +COX,KENYON,ONEALE,STUBBS,SUMOROK+    (BIRM)IJP
DECLAIS  77  CERN 77-16        +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP
GOYAL    77 PRD 16 2746        D.P.GOYAL,A.V.SODHI              (DELHI UNIV.)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
CAMERON  78 NP B143 189        +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LCIC)IJP
CAMERON2 78 NP B146 327        +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
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2030 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

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                 28  Y*1(2030, JP=     ) I=1       PRODUCTION EXPERIMENTS

                 SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

                 SEE THE NOTE TO THE F17 Y*1(2030), WHICH PRECEDES THIS
                 ENTRY.  HERE WE LIST ONLY PARAMETERS OF PEAKS IN CROSS
                 SECTIONS AND INVARIANT-MASS DISTRIBUTIONS.  THE CROSS-
     SECTION PEAKS ARE AT LEAST DOMINANTLY ASSOCIATED WITH THE Y*1(2030),
     BUT MAY CONTAIN A SMALL CONTRIBUTION FROM THE SUGGESTED BUT NOT ESTAB-
     LISHED OTHER RESONANCES IN THIS REGION.

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                 28  Y*1(2030) MASS (MEV) (PROD. EXP.)

M        (2022.0)   (20.0)          BLANPIED  65 CNTR  0 GAMMA P TO K+ Y*
M         2020.0      7.0           BUGG      68 CNTR    K-P, D TOTAL      6/68
M         2049.0      4.0           BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
M         2025.0     10.0           COOL      70 CNTR    K-P, D TOTAL     10/70
M        (2025.0)   (20.0)          LU        70 CNTR  0 GAMMA P TO K+ Y*  1/71
M         . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.8)

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                 28  Y*1(2030) WIDTH (MEV) (PROD. EXP.)

W         (120.0)   (20.0)          BLANPIED  65 CNTR  0
W          130.0     10.0           BUGG      68 CNTR                      6/68
W          126.0     11.0           BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
W          165.0                    COOL      70 CNTR    K-P, D TOTAL     10/70
W         ( 80.0)                   LU        70 CNTR  0 GAMMA P TO K+ Y*  1/71
W         . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                 28  Y*1(2030) PARTIAL DECAY MODES (PROD. EXP.)

                                                            DECAY MASSES
P1      Y*1(2030) INTO KBAR N                              497+ 939
P2      Y*1(2030) INTO KBAR N PI                           497+ 939+ 139

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                 28  Y*1(2030) BRANCHING RATIOS (PROD. EXP.)

R1      Y*1(2030) INTO (KBAR N)/TOTAL                     (P1)
R1         THESE VALUES OF ELASTICITIES ASSUME J=7/2 --
R1            0.131                 BUGG      68 CNTR                      6/68
R1            0.27     (0.02)       BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
R1            0.12                  COOL      70 CNTR    K-P, D TOTAL     10/70

R2      Y*1(2030) INTO KBAR N PI                          (P2)
R2              SEEN                BOCK      HBC

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Data Card Listings

Baryons

For notation, see key at front of Listings. Σ(2030), Σ(2070), Σ(2080), Σ(2100), Σ(2250)

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                       REFERENCES FOR Y*1(2030) (PROD. EXP.)

BLANPIED 65 PRL 14 741        +GREENBERG,HUGHES,KITCHING,LU,+ (YALE(CEA))
COOL     66 PRL 16 1228       +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
   SUPERSEDED BY COOL 70.
BUGG     68 PR 168 1466       +GILMORE,KNIGHT, +          (RHEL,BIRM,CAVE) I

BRICMAN  70 PL 31B 152        +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
COOL     70 PR D1 1887        +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
LU       70 PR D2 1846        +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

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Σ(2070)

F''_{15}

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             34  Y*1(2070, JP=5/2+) I=1

             THIS STATE HAS BEEN SUGGESTED BY CNLY ONE PARTIAL
             WAVE ANALYSIS ACROSS THIS REGION. IT NEEDS CONFIRMATION
             THE RESONANCE PROPOSED BY KANE IS TOO BROAD TO
             BE USED AS EVIDENCE.

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             34  Y*1(2070) MASS (MEV)

M        (2070.)    (10.)          BERTHON1  70 DPWA -  K- P TO SIG PI     1/71
M        (2057.0)                  KANE      72 DPWA    K-P TO SIGMA PI    1/73

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             34  Y*1(2070) WIDTH (MEV)

W         (140.)    (20.)          BERTHON1  70 DPWA -  K- P TO SIG PI     1/71
W         (906.0)                  KANE      72 DPWA    K-P TO SIGMA PI    1/73

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             34  Y*1(2070) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      Y*1(2070) INTO KBAR N                          497+ 939
P2      Y*1(2C70) INTO SIGMA PI                        1197+ 139

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             34  Y*1(2070) BRANCHING RATIOS

R1      Y*1(2C70) FROM KBAR N TO SIGMA                 SQRT(P1*P2)
R1         (+.12)    (.02)         BERTHON1  70 DPWA -  K- P TO SIG PI     1/71
R1         (+0.104)                KANE      72 DPWA    K-P TO SIGMA PI    1/73

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                       REFERENCES FOR Y*1(2070)

BERTHON1 70 NP B24 417        +VRANA,BUTTERWORTH,+      (CDEF,RHEL,SACLAY)IJP
KANE     72 PR D5 1583        D F KANE                                (LBL)

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Σ(2080)

P'''_{13}

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             88  Y*1(2080, JP=3/2+) I=1
             SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

             SUCH A RESONANCE IS SUGGESTED BY SOME BUT NOT ALL
             PARTIAL-WAVE ANALYSES ACROSS THIS REGION.  UNTIL THERE
             IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN
             BARYON TABLE.

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             88  Y*1(2080) MASS (MEV)

M         (2C82.0)   (4.0)         COX       70 DPWA -  K- N TO LAM PI     6/70
M         (2070.0)   (30.0)        LITCHFIEL 70 DPWA -0 K- N TO LAM PI     6/70
M    1     2120.      40.          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M    1  FROM SOLUTION 1 OF BAILLON 75.                                    1/76
M    2     2140.      40.          BAILLON   75 IPWA    KBAR N TO LAM PI  1/76
M    2  FROM SOLUTION 2 OF BAILLON 75.                                    1/76
M          2140.      30.          BELLEFO1  75 DPWA  0 K- P TO LAM PIO  11/75
M   3      2070. TO 2120.          BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
M   3   SUPERSEDES BELLEFO1 75.                                           2/77
M    4     2091.       7.          CORDEN    76 DPWA  - K- N TO PI- LAM   2/77
M    4  PREFERRED SOLUTION 3, SEE CORDEN 76 FOR OTHER POSSIBLILITES,      2/77
M    4  INCLUDING A D15 AT THIS MASS.                                     2/77
M    4  CORDEN 76 INCLUDES THE DATA OF COX 70 AS A SUBSAMPLE.
M          . . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

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             88  Y*1(2080) WIDTH (MEV)

W          (87.0)    (20.0)        COX       70 DPWA -  K- N TC LAM PI     6/70
W         (250.0)    (40.0)        LITCHFIEL 70 DPWA -0 K- N TO LAM PI     6/70
W    1     240.       50.          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W    2     200.       50.          BAILLON   75 IPWA    KBAR N TO LAM PI  1/76
W          180.       20.          BELLEFO1  75 DPWA  0 K- P TO LAM PIO  11/75
W   3     (100.)                   BELLEFCN  76 IPWA  0 K- P TO LAM PI    2/77
W    4     186.       48.          CORDEN    76 DPWA  - K- N TO PI- LAM   2/77
W          . . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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             88  Y*1(2080) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      Y*1(2080) INTO KBAR N                          497+ 939
P2      Y*1(2080) INTO LAMBDA PI                       1115+ 139

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             88  Y*1(2080) BRANCHING RATIOS

R1      Y*1(2080) FROM KBAR N TO LAMBDA PI             SQRT(P1*P2)
R1         (-0.16)    (0.03)       COX       70 DPWA -  K- N TO LAM PI     6/70
R1         (-0.09)    (0.03)       LITCHFIEL 70 DPWA -0 K- N TO LAM PI     6/70
R1   1       -.13      .04         BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R1   2       -.13      .04         BAILLON   75 IPWA    KBAR N TO LAM PI  1/76
R1           +.19      .03         BELLEFO1  75 DPWA  0 K- P TO LAM PIO  11/75
R1  3       (-.10)                 BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
R1   4       -.10      .03         CORDEN    76 DPWA  - K- N TO PI- LAM   2/77
R1         . . . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

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                       REFERENCES FOR Y*1(2080)

COX      70 NP B19 61         +ISLAM, COLLEY, +      (BIRM,EDIN,GLAS,LOIC)IJP
LITCHFIE 70 NP B22 269        P J LITCHFIELD                 (RUTHERFORD)IJP
BAILLON  75 NP B94 39         P. BAILLON,P. J. LITCHFIELD     (CERN,RHEL)IJP
BELLEFO1 75 NP B90 1          DE BELLEFON,BERTHON,BRUNET+     (CDEF,SACL)IJP

BELLEFON 76 NP B109 129       DE BELLEFON,BERTHON                  (CDEF)IJP
CORDEN   76 NP B104 382       +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP

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Σ(2100)

G_{17}

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             26  Y*1(2100, JP=7/2-) I=1
             SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

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             26  Y*1(2100) MASS (MEV)

M         (2C60.0)   (20.0)        GALTIERI  70 DPWA  0 K-P TO LAMBDA PI  7/70
M         (2120.0)   (30.0)        GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70

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             26  Y*1(2100) WIDTH (MEV)

W          (70.0)    (30.0)        GALTIERI  70 DPWA  0 K-P TO LAMBDA PI  7/70
W         (135.0)    (30.0)        GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70

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             26  Y*1(2100) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      Y*1(2100) INTO KBAR N                          497+ 939
P2      Y*1(2100) INTO LAMBDA PI                       1115+ 134
P3      Y*1(2100) INTO SIGMA PI                        1197+ 139

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             26  Y*1(2100) BRANCHING RATIOS

R1      Y*1(2100) FROM KBAR N TO LAMBDA PI             SQRT(P1*P2)
R1         (-0.07)    (0.02)       GALTIERI  70 DPWA  0 K-P TO LAMBDA PI  7/70

R2      Y*1(2100) FROM KBAR N TO SIGMA PI              SQRT(P1*P3)
R2         (+0.13)    (0.02)       GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70

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                       REFERENCES FOR Y*1(2100)

GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                    (LRL)IJP

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Σ(2250) BUMPS

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             48  Y*1(2250, JP=    ) I=1         PRODUCTION EXPERIMENTS
             SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

             THE PARTIAL-WAVE ANALYSIS RESULTS ARE TOO WEAK TO
             WARRANT SEPARATING THEM FROM THE PRODUCTION AND CROSS-
             SECTION EXPERIMENTS.
   LASINSKI 71 IN KBAR N, USING A POMERON+RESONANCES MODEL, AND
BELLEFON1 76, BELLEFON 77, AND BELLEFON 78 (COLLEGE DE FRANCE-
SACLAY GROUP) IN DPWA'S OF KBAR N TO LAMBDA PI, SIGMA PI, AND KBAR N,
RESPECTIVELY, SUGGEST THE PRESENCE OF TWO RESONANCES AROUND THIS
MASS VALUE.

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             48  Y*1(2250) MASS (MEV) (PROD. EXP.)

M         (2245.0)                 BLANPIED  65 CNTR    GAMMA P TO K+ Y*
M         (2299.0)    (6.0)        BOCK      65 HBC     PBAR P 5.7 BEV/C
M          2250.0      7.0         BUGG      68 CNTR    K-P, D TOTAL       6/68
M          2280.      14.0         AGUILAR   70 HBC  +  K- 3.9-4.6 GEV/C   5/70
M          2237.0     11.0         BRICMAN   70 CNTR  0 TOTAL AND CH EX    6/70
M          2255.0     10.0         COOL      70 CNTR    K-P, D TOTAL      10/70
M         (2250.0)   (20.0)        LU        70 CNTR  0 GAMMA P TO K+ Y*  1/71
M   B     (2260.)    (30.)         BELLEFO1  75 DPWA    D5 WAVE           11/75
M   B     (2215.)    (10.)         BELLEFO1  75 DPWA    G9 OR H11 WAVE    11/75
M   B   EVIDENCE FOR 2 RESONANCES IN THIS LAMBDA PI DPWA                  11/75
M    1     2300.      30.          BELLEFO2  75 HBC   0 K- P TO XI*0 KO   11/75
M    V     2251.      30.      20. VANHORN   75 DPWA  0 K-P TO LAM PIO    11/75
M    V    VANHORN72 VALUE FROM A DPWA THAT FINDS JP=5/2+.
M   2     (2260.)                  BELLEFON  76 IPWA  0 D5 WAVE            2/77
M   2     (2215.)                  BELLEFON  76 IPWA  0 G9 WAVE            2/77
M   2   SUPERSEDES BELLEFO1 75.                                            2/77
M          2275.      20.          BELLEFON  77 DPWA  0 D5 WAVE           11/77
M          2215.      20.          BELLEFCN  77 DPWA  0 G9 WAVE           11/77
M          2270.      50.          BELLEFON  78 DPWA  0 D5 WAVE            1/78
M          2210.      30.          BELLEFON  78 DPWA  0 G9 WAVE            1/78
M          . . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

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Baryons

Σ(2250), Σ(2455), Σ(2620)

Data Card Listings

For notation, see key at front of Listings.

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                      48  Y*1(2250) WIDTH (MEV) (PROD. EXP.)

W          (150.0)                         BLANPIED  65 CNTR    GAMMA P TO K+ Y*
W           (21.0)   (17.0)    (21.0)      BOCK      65 HBC     PBAR P 5.7 GEV/C
W          230.0      20.0                 BUGG      68 CNTR    K-P, D TOTAL        6/68
W          100.0      20.0                 AGUILAR   70 HBC  +  K- 3.9-4.6 GEV/C    5/70
W          164.0      50.0                 BRICMAN   70 CNTR  0 TOTAL AND CH EX     6/70
W          (170.0)                         COOL      70 CNTR    K-P, D TOTAL       10/70
W          (125.0)                         LU        70 CNTR  0 GAMMA P TO K+ Y*    1/71
W   B      (100.)     (20.)                BELLEFO1  75 DPWA    D5 WAVE            11/75
W   B       (60.)     (40.)    (20.)       BELLEFO1  75 DPWA    G9 OR H11 WAVE     11/75
W    1      130.       20.                 BELLEFO2  75 HBC   0 K- P TO XI*0 KO    11/75
W    V      192.       30.                 VANHORN   75 DPWA  0 K-P TO LAM PIO     11/75
W   2      (100.)                          BELLEFON  76 IPWA  0 D5 WAVE             2/77
W   2      (140.)                          BELLEFON  76 IPWA  0 G9 WAVE             2/77
W            70.       20.                 BELLEFON  77 DPWA  0 D5 WAVE            11/77
W            60.       20.                 BELLEFON  77 DPWA  0 G9 WAVE            11/77
W           120.       40.                 BELLEFON  78 DPWA  0 D5 WAVE             1/78
W            80.       20.                 BELLEFON  78 DPWA  0 G9 WAVE             1/78
W          . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 2.7)
              SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                      48  Y*1(2250) PARTIAL DECAY MODES (PROD. EXP.)

                                                              DECAY MASSES
P1      Y*1(2250) INTO KBAR N                                497+ 939
P2      Y*1(2250) INTO LAMBDA PI                            1115+ 134
P3      Y*1(2250) INTO SIGMA PI                             1197+ 139
P4      Y*1(2250) INTO KBAR N PI                             497+ 939+ 139
P5      Y*1(2250) INTO XI*1/2(1530) K                       1533+ 497

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                      48  Y*1(2250) BRANCHING RATIOS (PROD. EXP.)

R1      Y*1(2250) INTO (KBAR N)/TOTAL                      (P1)
R1              .08       .02              BELLEFON  78 DPWA  0 D5 WAVE             1/78
R1              .02       .01              BELLEFON  78 DPWA  0 G9 WAVE             1/78
R1         . . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 2.7)

R2      Y*1(2250) FROM KBAR N TO LAMBDA PI                 SQRT(P1*P2)
R2          (-0.18)(FOR JP=9/2-)           GALTIERI  70 DPWA    K-P TO LAMBDA PI  10/70
R2  B          (+.12)    (.03)             BELLEFO1  75 DPWA    D5 WAVE            11/75
R2  B          (-.09)    (.02)             BELLEFO1  75 DPWA    G9 OR H11 WAVE     11/75
R2   V          -.16      .03              VANHORN   75 DPWA  0 K-P TO LAM PIO     11/75
R2  2          (+.11)                      BELLEFON  76 IPWA  0 D5 WAVE             2/77
R2  2          (-.10)                      BELLEFON  76 IPWA  0 G9 WAVE             2/77
              SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

R3      Y*1(2250) FROM KBAR N TO SIGMA PI                  SQRT(P1*P3)
R3          (+0.07)(FOR JP=9/2-)           GALTIERI  70 DPWA    K-P TO SIGMA PI   10/70
R3              +.06      .02              BELLEFON  77 DPWA  0 D5 WAVE            11/77
R3              -.03      .02              BELLEFON  77 DPWA  0 G9 WAVE            11/77
R3         . . . . . . . . . .
R3  AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

R4      Y*1(2250) INTO (KBAR N)/(SIGMA PI)                 (P1)/(P3)
R4          (0.18) OR LESS                 BARNES    69 HBC  +  1 STAN DEV LIMIT 10/69

R5      Y*1(2250) INTO (LAMBDA PI)/(SIGMA PI)              (P2)/(P3)
R5          (0.18) OR LESS                 BARNES    69 HBC  +  1 STAN DEV LIMIT 10/69

R6      Y*1(2250) FROM K- P TO XI*1/2(1530)0 KO            SQRT(P1*P5)        11/75
R6   1          .09       .02              BELLEFO2  75 HBC   0 K- P TO XI*0 KO   11/75
R6   1  SEEN IN DD5 WAVE IN NEUTRAL CHANNEL ONLY, ISOSPIN UNDETERMINED.           11/75

R7      Y*1(2250) INTO (KBAR N)/TOTAL                      (J+1/2)*(P1)
R7         J IS NOT DETERMINED IN THESE EXPTS.  THE FOLLOWING IS (J+1/2)*P1.
R7          (0.47)                         BUGG      68 CNTR                        3/78
R7          (0.16)    (0.12)               BRICMAN   70 CNTR  0 TOTAL AND CH EX     3/78
R7          (0.42)                         COOL      70 CNTR    K-P, D TOTAL        3/78

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                                    REFERENCES FOR Y*1(2250) (PROD. EXP.)
BLANPIED 65 PRL 14 741              +GREENBERG,HUGHES,KITCHING, +    (YALE(CEA))
BOCK     65 PL 17 166               +COOPER,FRENCH,KINSON, +       (CERN,SACLAY)
BUGG     68 PR 168 1466             +GILMORE,KNIGHT, +          (RHEL,BIRM,CAVE) I
BARNES   69 PRL 22 479              +FLAMINIO,MONTANET,SAMIOS +       (BNL+SYRA)

AGUILAR  70 PRL 25 58               AGUILAR-BENITEZ, BARNES, +        (BNL,SYRA)
BRICMAN  70 PL 31B 152              +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
COOL     70 PR D1 1887              +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
GALTIERI 70 DUKE CONF 173           A BARBARO-GALTIERI                    (LRL)IJP
LU       70 PR D2 1846              +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

BELLEFO1 75 NP B90 1                DE BELLEFO2,BERTHON,BRUNET+      (CDEF+SACL)IJP
BELLEFO2 75 NC 28A 289              DE BELLEFO2,BERTHON,BILLOIR+     (CDEF,SACL)
VANHORN  75 NP B87 145              A. J. VAN HORN                        (LBL)IJP
    ALSO 75 NP B87 157              A. J. VAN HORN                        (LBL)IJP

BELLEFON 76 NP B109 129             DE BELLEFON,BERTHON                  (CDEF)IJP
BELLEFON 77 NC 37A 175              DE BELLEFON,BERTHON,BILLOIR+     (CDEF+SACL)IJP
BELLEFON 78 NC 42A 403              +BERTHON,BILLOIR,BRUNET+         (CDEF+SACL)IJP

                                    PAPERS NOT REFERRED TO IN DATA CARDS

COOL     66 PRL 16 1228             +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
    SUPEREDED BY COOL 70.
DAUBER   66 PL 23 154               +SCHLEIN, SLATER, STORK, TICHO  (UCLA(LRL)) J
    SUGGESTS. J*9/2 RESONANT BEHAVIOR IN SIGMA- PI+, BUT APPEARS
           INCONSISTENT WITH PARAMETERS OF COOL 66.
DAUM     68 NP B7 19                +ERNE, LAGNAUX, SENS, STEUER, UDO     (CERN)JP
LASINSKI 71 NP  B29  125            T A LASINSKI                          (EFI)IJP
HEMINGWA 75 NP B91 12               HEMINGWAY,EADES,HARMSEN+   (CERN,HEID,MPIM)IJP

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Σ(2455) BUMPS

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53  Y*1(2455, JP=     ) I=1         PRODUCTION EXPERIMENTS

        SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.
        THERE IS ALSO SOME SLIGHT EVIDENCE FOR Y* STATES IN
   THIS MASS REGION FROM THE REACTION GAMMA + P TO K+ + MISSING MASS --
   SEE GREENBERG 68.

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                     53  Y*1(2455) MASS (MEV) (PROD. EXP.)

M          2455.0      7.0            BUGG      68 CNTR    K-P, D TOTAL        6/68
M          2455.0     10.0            ABRAMS    70 CNTR    K-P, D TOTAL       10/70
M          . . . . . . . . . .
M   AVG    2455.0      5.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT2455.0      6.1     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                     53  Y*1(2455) WIDTH (MEV) (PROD. EXP.)

W           100.0     20.0            BUGG      68 CNTR                        6/68
W           140.0                     ABRAMS    70 CNTR    K-P, D TOTAL       10/70

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                     53  Y*1(2455) PARTIAL DECAY MODES (PROD. EXP.)

                                                            DECAY MASSES
P1      Y*1(2455) INTO KBAR N                              497+ 939

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                     53  Y*1(2455) BRANCHING RATIOS (PROD. EXP.)

R1      Y*1(2455) INTO (KBAR N)/TOTAL                     (P1)
R1         J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1          (0.3)                     BUGG      68 CNTR                        6/68
R1           0.39                     ABRAMS    70 CNTR    K-P, D TOTAL       10/70
R1  C       (0.05)    (0.05)          BRICMAN   70 CNTR  0 TOTAL AND CH EX     6/70
R1  C    FIT OF TOTAL CROSS SECTION GIVEN BY BRICMAN 70 IS POOR IN
R1  C    THIS REGION.

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                              REFERENCES FOR Y*1(2455) (PROD. EXP.)

BUGG     68 PR 168 1466       +GILMORE,KNIGHT, +          (RHEL,BIRM,CAVE) I
ABRAMS   70 PR 1D 1917        +COOL, GIACOMELLI, KYCIA, LEONTIC, +  (BNL) I
BRICMAN  70 PL 31B 152        +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)

                              PAPERS NOT REFERRED TO IN DATA CARDS
ABRAMS   67 PRL 19 678        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI, +  (BNL)
    SUPERSEDED BY ABRAMS 70.
GREENBER 68 PRL 20 221        GREENBERG, HUGHES, LU, MINEHART, +    (YALE)

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Σ(2620) BUMPS

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54  Y*1(2620, JP=     ) I=1         PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

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                     54  Y*1(2620) MASS (MEV) (PROD. EXP.)

M          2620.0     15.0            ABRAMS    70 CNTR    K-P, D TOTAL       10/70
M          2542.      22.             DIBIANCA  75 DBC     XI K PI             1/76
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.9)

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                     54  Y*1(2620) WIDTH (MEV) (PROD. EXP.)

W          (175.0)                    ABRAMS    70 CNTR    K-P, D TOTAL       10/70
W           221.      81.             DIBIANCA  75 DBC     XI K PI             1/76

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                     54  Y*1(2620) PARTIAL DECAY MODES (PROD. EXP.)

                                                            DECAY MASSES
P1      Y*1(2620) INTO KBAR N                              497+ 939

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                     54  Y*1(2620) BRANCHING RATIOS (PROD. EXP.)

R1      Y*1(2620) INTO (KBAR N)/TOTAL                     (P1)
R1         J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1          (0.32)                    ABRAMS    70 CNTR    K-P, D TOTAL       10/70
R1           0.36      0.12           BRICMAN   70 CNTR  0 TOTAL AND CH EX     6/70

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                              REFERENCES FOR Y*1(2620) (PROD. EXP.)

ABRAMS   67 PRL 19 678        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI, +  (BNL)
    SUPERSEDED BY ABRAMS 70.
ABRAMS   70 PR 1D 1917        +COOL, GIACOMELLI, KYCIA, LEONTIC, +  (BNL) I
BRICMAN  70 PL 31B 152        +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)

DIBIANCA 75 NP B98 137        DIBIANCA,ENDORFR                      (CARN)

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Data Card Listings

For notation, see key at front of Listings.

Baryons

Σ(3000), Σ(3170), EXOTIC HYPERONS, Ξ's

Σ(3000) BUMPS →

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59  Y*1(3000, JP=    ) I=1        PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

ENHANCEMENT IN LAMBDA PI AND KBAR N INVARIANT MASS
SPECTRA AND IN MISSING MASS OF NEUTRALS RECOILING
AGAINST KO.  EVIDENCE NOT CONCLUSIVE.  OMITTED FROM
TABLE.

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                    59  Y*1(3000) MASS (MEV) (PROD. EXP.)

M       (3000.0)                  EHRLICH   66 HBC   0 PI-P 7.91 BEV/C   9/66

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                    59  Y*1(3000) PARTIAL DECAY MODES (PROD. EXP.)

                                                        DECAY MASSES
P1      Y*1(3000) INTO KBAR N                          497+ 939
P2      Y*1(3000) INTO LAMBDA PI                      1115+ 139

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                         REFERENCES FOR Y*1(3000) (PROD. EXP.)

EHRLICH  66 PR 152 1194       R EHRLICH, W SELOVE, H YUTA     (PENN(BNL)) I

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Σ(3170) BUMPS →

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118  Y*1(3170, JP=     ) I=1       PRODUCTION EXPERIMENTS

 SEEN BY AMIRZADEH1 79 AS A NARROW 6.5 STD. DEV.
 ENHANCEMENT IN THE REACTION K-P --> Y* PI- USING DATA
 FROM TWO INDEPENDENT HIGH STATISTICS BUBBLE CHAMBER
 EXPERIMENTS AT 8.25 AND 6.5 GEV/C.  THE DOMINANT DECAY
 MODES ARE INTO MULTI-BODY, MULTI-STRANGE FINAL STATES
 AND THE PRODUCTION IS VIA I=3/2 BARYON EXCHANGE.  I=1
 IS FAVORED.
 IN NEED OF CONFIRMATION.  OMITTED FROM TABLES.

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                 118  Y*1(3170) MASS  (MEV) (PROD. EXP.)

M       35 3170.      5.          AMIRZAD1   79 HBC  +  K-P TO Y* PI-    12/79*

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                 118  Y*1(3170) WIDTH  (MEV) (PROD. EXP.)

W  C    35  (20.)   OR LESS       AMIRZAD1   79 HBC  +  K-P TO Y* PI-    12/79*
W  C    OBSERVED WIDTH CONSISTENT WITH EXPERIMENTAL RESOLUTION.

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                 118  Y*1(3170) PARTIAL DECAY MODES (PROD. EXP.)

                                                        DECAY MASSES
P1      Y*1(3170) INTO LAMBDA K KBAR + PIONS
P2      Y*1(3170) INTO SIGMA K KBAR + PIONS
P3      Y*1(3170) INTO XI K + PIONS

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                 118  Y*1(3170) BRANCHING RATIOS (PROD. EXP.)

R1      Y*1(3170) INTO LAMBDA K KBAR + PICNS           (P1)
R1          SEEN                  AMIRZAD1   79 HBC  +  K-P TO Y* PI-    12/79*

R2      Y*1(3170) INTO SIGMA K KBAR + PIONS            (P2)
R2          SEEN                  AMIRZAD1   79 HBC  +  K-P TO Y* PI-    12/79*

R3      Y*1(3170) INTO XI K + PIONS                    (P3)
R3          SEEN                  AMIRZAD1   79 HBC  +  K-P TO Y* PI-    12/79*

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                         REFERENCES FOR Y*1(3170) (PROD. EXP.)

AMIRZAD1 79 PL 89B 125        AMIRZADEH+  (BIRM+CERN+GLAS+MSU+LPNP+CAVE+)I

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EXOTIC HYPERON CROSS SECTION LIMITS

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                 31  EXOTIC HYPERON CROSS SECTION LIMITS

                 THIS IS NOT A COMPLETE LIST.  WE TABULATE
                 ONLY FROM 1970 ON.

CS  UNITS MICROBARNS
CS  G       (20.)   OR LESS             GALTIERI  68 DBC  -- K-N TO SG-PI-PIO  7/70
CS  G  ABOVE LIMIT FOR MASS <  2.15 GEV AND WIDTH <  60 MEV- (2.1 GEV/C K-)  7/70
CS  A       (40.)   OR LESS             GALTIERI  68 DBC  -- K-N TO SG-PI-PIO  7/70
CS  A  ABOVE LIMIT FOR MASS <  2.3 GEV AND WIDTH  < 120 MEV- (2.7 GEV/C K-)   7/70
CS  X        (4.7)  OR LESS  CL=.90   BRIEFEL   75 DBC  -- K-D 2.87 GEV/C     3/79*
CS  X   WIDTH < 40 MEV. K-N --> (XI- PI-) K+
CS  Y        (1.4)  OR LESS  CL=.90   BRIEFEL   75 DBC  -- K-D 2.87 GEV/C     3/79*
CS  Y   WIDTH < 40 MEV. K-N --> (XI- PI- PIO) K+
CS  Z        (5.4)  OR LESS  CL=.90   BRIEFEL   75 DBC  -- K-D 2.87 GEV/C     3/79*
CS  Z   WIDTH < 60 MEV. K-N --> (XI- PI-) K+ PIO
CS  B        (8.6)  OR LESS  CL=.90   KATSOUFI  78 DBC  -- K-D 2.87 GEV/C     3/79*
CS  B   WIDTH < 60 MEV. K-N --> (SIGMA- PI-) PI+
CS  C       (13.3)  OR LESS  CL=.90   KATSOUFI  78 DBC  -- K-D 2.87 GEV/C     3/79*
CS  C   WIDTH < 120 MEV. K-N --> (SIGMA- PI-) PI+
CS  D        (6.9)  OR LESS  CL=.90   KATSOUFI  78 DBC  -- K-D 2.87 GEV/C     3/79*
CS  D   MASS > 2 GEV. WIDTH < 60 MEV. K-N --> (SIGMA- PI-) PI+
CS  E        (7.7)  OR LESS  CL=.90   KATSOUFI  78 DBC  -- K-D 2.87 GEV/C     3/79*
CS  E   MASS > 2 GEV. WIDTH < 120 MEV. K-N --> (SIGMA- PI-) PI+
CS  F       (17.)   OR LESS  CL=.90   KATSOUFI  78 DBC  -- K-D 2.87 GEV/C     3/79*
CS  F   WIDTH < 60 MEV. K-N --> (SIGMA- PI- PIO) PI+
CS  H       (23.)   OR LESS  CL=.90   KATSOUFI  78 DBC  -- K-D 2.87 GEV/C     3/79*
CS  H   WIDTH < 120 MEV. K-N --> (SIGMA- PI- PIO) PI+
CS  I       (28.)   OR LESS  CL=.90   KATSOUFI  78 DBC  -- K-D 2.87 GEV/C     3/79*
CS  I   WIDTH < 80 MEV. K-N --> (SIGMA- PI-) PI- PIO

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                         REFERENCES FOR EXOTIC HYPERONS

GALTIERI 68 PRL  21 573         A.BARBARO-GALTIERI,CHADWICK +      (LRL+SLAC)
BRIEFEL  75 PRD  12 1859        +GOUREVITCH,KIRSCH+      (BRAN+UMD+SYRA+TUFT)I
KATSOUFI 78 PRD  18 16          KATSOUFIS,CANTER,MANN,SCHNEPS+   (TUFT+BRAN)I

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Note on Ξ Resonances

The Ξ resonance situation has long been unsettled. This is mainly because: (1) Ξ^*'s can only be produced as part of a final state, $K^-p \to \Xi^* +$ others, where the analysis is more complicated than if direct formation were possible; (2) they are so-produced with small cross sections (typically a few μb); and (3) the final states are in general topologically complicated and difficult to study with purely electronic techniques. Thus over the years our knowledge of Ξ^* spectroscopy has come wholly from bubble chamber experiments, where the number of events available are small.

Until fairly recently only the Ξ(1530) could be considered as really well established. However, the 1978 edition of this review[1] saw a significant improvement in our understanding of the Ξ^* spectrum with the data of GAY 76 and HEMINGWAY 77. The Ξ(1820) and Ξ(2030) were definitely established as narrow states (with widths ~20 MeV), and the spin of the Ξ(1820) was determined to be 3/2 (TEODORO 77).

As far as the other Ξ^* states are concerned, the situation continues much as before, although there is some evidence for a new Ξ(2370) (AMIRZADEH2 79). There is probably at least one other state in the 1850-2000 MeV region and there are indications of several others above 2000 MeV. Indeed, numerous states are predicted to exist below 2500 MeV and the broad Ξ(1940) could well be a mixture of several.[2] Thus for the time being, we are still forced to group together rather disparate observations and await more new results. The disagreement among various experiments is indicated by means of ideograms in the Data Card Listings.

More new results may shortly be forthcoming from two large bubble chamber experiments currently in progress (MORRIS 75, AMIRZADEH2 79). In addition, future experiments with the MPS at BNL and with hyperon beams at both FNAL and CERN[3] may further clarify the situation.

The table following this note gives our evaluation of the status of the Ξ resonances, based on data available at this time.

Baryons

Ξ's, Ξ^-, Ξ^0, Ξ(1530)

Data Card Listings

For notation, see key at front of Listings.

References

1. Particle Data Group, Phys. Lett. 75B, 1 (1978).
2. R.J.Hemingway, Proc. of the Topical Conference on Baryon Resonances, Oxford, 1976, edited by R.T.Ross and D.H.Saxon (Science Research Council, Chilton).
3. M. Bourquin et al., Nucl. Phys. B153, 13 (1979).

For other references see the Data Card Listings.

STATUS OF XI* RESONANCES

THOSE WITH AN OVERALL STATUS OF *** OR **** ARE INCLUDED IN THE MAIN BARYON TABLE. THE OTHERS AWAIT CONFIRMATION.
IN THE PAST WE HAVE LOWERED OUR STANDARDS FOR XI* RESONANCES AND TABULATED STATES EVEN THOUGH THEY HAD ONLY BEEN SEEN AT LOW LEVELS OF STATISTICAL SIGNIFICANCE. NOW THAT NEW HIGH STATISTICS DATA IS BECOMING AVAILABLE, WE PROPOSE TO ADOPT SOMEWHAT STRICTER CRITERIA.

			STATUS AS SEEN IN --				
PARTICLE	LIJ	OVERALL STATUS	XI PI	LAM K	SIG K	XI* PI	OTHER CHANNELS
XI(1317)	P11	****					WEAK TO LAM PI
XI(1530)	P13	****	****				
XI(1630)		**	**				
XI(1680)		**		*	**		
XI(1820)	13	***	*	***	**	***	
XI(1940)		**	**			**	
XI(2030)	1	***		**	***		
XI(2120)		*		*			
XI(2250)		*					3-BODY DECAYS
XI(2370)	1	**					3-BODY DECAYS
XI(2500)		**		**	**		3-BODY DECAYS

**** GOOD, CLEAR, AND UNMISTAKABLE.
*** GOOD, BUT IN NEED OF CLARIFICATION OR NOT ABSOLUTELY CERTAIN.
** NEEDS CONFIRMATION.
* WEAK.

S=-2 I=1/2 HYPERON STATES (Ξ)

Ξ^-

22 XI-(1321, JP=1/2) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

Ξ^0

23 XI0(1314, JP=1/2) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

Ξ(1530) 49 XI*1/2(1530, JP=3/2+) I=1/2 **P_{13}**

THIS IS THE ONLY WELL-ESTABLISHED XI* WHOSE PROPERTIES ARE ALL AT LEAST REASONABLY WELL-KNOWN. SPIN-PARITY 3/2+ IS FAVOURED BY THE DATA.

WE DO NOT USE DETERMINATIONS OF THE MASS AND THE WIDTH OF THIS STATE UNLESS THEY ARE ACCOMPANIED BY SOME DISCUSSION OF SYSTEMATICS AND RESOLUTION.

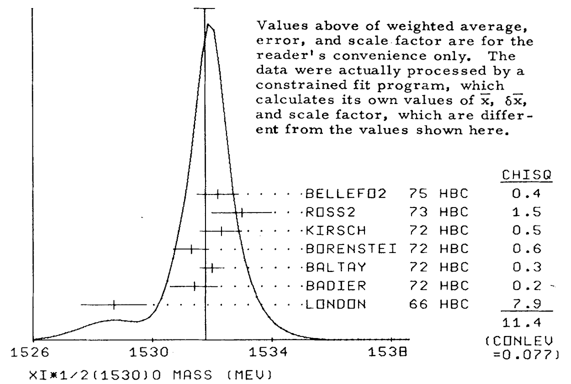
49 XI*1/2(1530) MASS (MEV)

```
M    MIXED CHARGES
M       20(1535.)                           BERTANZA  62 HBC  -0 K-P 2.3 GEV/C
M       55(1529.0)     (5.0)                PJERROU   62 HBC  -0 K-P 1.8 GEV/C
M         (1532.0)     (2.0)                BADIER    64 HBC  -0 K-P 3 GEV/C

M-   NEGATIVE CHARGE ONLY
M-      38 1535.7       3.2                 LONDON    66 HBC  -  K-P 2.24 GEV/C     7/66
M-     334(1534.7)     (1.1)                BALTAY    72 HBC  -  K-P 1.75 GEV       1/73
M-     185 1536.2       1.6                 KIRSCH    72 HBC  -  K-P 2.87GEV/C      2/72
M-         1535.3       2.0                 ROSS2     73 HBC  -  XI KBAR PI (PI)    2/74
M-      48(1540.)      (3.)                 BERTHON   74 HBC  -  QUASI 2 BODY CS   10/74
M-         1534.5       1.2                 BELLEFO2  75 HBC  -  K-P TO XI- K PI   11/75
M-         . . . . . . . . .
M-   AVG       1535.18     0.84    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M-   STUDENT1535.18        0.92    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M-   FIT       1534.97     0.63   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
```

```
MO   NEUTRAL CHARGE ONLY
MO      76 1528.7       1.1                 LONDON     66 HBC   0 K-P 2.24 GEV/C      7/66
MO      59 1531.4       0.8                 BADIER     72 HBC   0 K-P AT 3.95GEV/C 10/71
MO    1262 1532.0       0.4                 BALTAY     72 HBC   0 K-P 1.75 GEV        1/73
MO     324 1531.3       0.6                 BORENSTEI  72 HBC   0 K-P 2.2GEV/C        2/72
MO     286 1532.3       0.7                 KIRSCH     72 HBC   0 K-P 2.87GEV/C       2/72
MO         1533.0       1.0                 ROSS2      73 HBC     XI KBAR PI (PI)     2/74
MO      97(1533.6)     (1.4)                BERTHON    74 HBC   0 QUASI 2 BODY CS    10/74
MO         1532.2        .7                 BELLEFO2   75 HBC   0 K-P TO XI- K PI    11/75
MO      80(1527.)      (6.)                 SIXEL      79 HBC   0 INCL. K-P 10 GEV   1/80*
MO     100(1535.)      (4.)                 SIXEL      79 HBC   0 INCL. K-P 16 GEV   1/80*
MO         . . . . . . . . . .
MO   AVG       1531.78     0.34    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
MO   STUDENT1531.84        0.28    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
MO   FIT       1531.80     0.31   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
                                  (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 1531.78 ± 0.34
ERROR SCALED BY 1.4



Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\bar{x}$, $\delta\bar{x}$, and scale factor, which are different from the values shown here.

49 (XI*-) - (XI*0) MASS DIFFERENCE (MEV)

```
D              5.7       3.0           PJERROU   65 HBC  -0 1.8-1.95 GEV/C    7/66
D    R        (7.0)     (4.0)          LONDON    66 HBC  -0 2.24 GEV/C        7/66
D              2.0       3.2           MERRILL   66 HBC  -0 1.7-2.7 GEV/C     7/66
D              2.7       1.0           BALTAY    72 HBC  -0 K-P 1.75 GEV      1/73
D    R        (3.9)     (1.8)          KIRSCH    72 HBC  -0 K- P 2.87 GEV/C   2/72
D    R     REDUNDANT WITH DATA IN MASS LISTING.
D          . . . . . . . . .
D    AVG       2.92      0.91    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D    STUDENT   2.90      0.99    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
D    FIT       3.17      0.64   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
```

49 XI*1/2(1530) WIDTH (MEV)

```
W    MIXED CHARGES
W       20  (35.)    OR LESS               BERTANZA  62 HBC  -0 K-P 2.3 GEV/C

W-   NEGATIVE CHARGE ONLY
W-          7.8       3.5       7.8        BALTAY    72 HBC  -  K-P 1.75 GEV       1/73
W-         16.2       4.6                  KIRSCH    72 HBC  -  XI- PI0,XI0 PI-    2/72
W-          8.3       3.6                  ROSS2     73 HBC  -  XI KBAR PI (PI)    2/74
W-          9.6       2.8                  BELLEFO2  75 HBC  -  K-P TO XI- K PI   11/75
W-        . . . . . . . . .
W-   AVG      10.1       1.9    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W-   STUDENT  10.0       2.1    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

WO   NEUTRAL CHARGE ONLY
WO          7.0       2.0                  SCHLEIN   63 HBC  0 1.8, 1.95 GEV/C
WO          7.0       7.0                  BERGE     66 HBC  0 1.5-1.7 GEV/C      7/66
WO          8.5       3.5                  LONDON    66 HBC  0 2.24 GEV/C         7/66
WO         11.0       2.0                  BADIER    72 HBC  0 K-P AT 3.95GEV/C 10/71
WO          9.0       0.7                  BALTAY    72 HBC  0 K-P 1.75 GEV       1/73
WO          8.4       1.4                  BORENSTEI 72 HBC  0 XI- PI+ MODE       2/72
WO         11.0       1.8                  KIRSCH    72 HBC  0 XI- PI+            2/72
WO          9.1       2.4                  ROSS2     73 HBC  0 XI KBAR PI (PI)    2/74
WO          9.5       1.2                  BELLEFO2  75 HBC  0 K-P TO XI- K PI   11/75
WO   R   80 (19.)    (6.)                  SIXEL     79 HBC  0 INCL. K-P 10 GEV  1/80*
WO   R  100 (14.)    (5.)                  SIXEL     79 HBC  0 INCL. K-P 16 GEV  1/80*
WO        . . . . . . . . .
WO   AVG       9.14      0.48    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
WO   STUDENT   9.13      0.53    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
20   R     EXPERIMENTAL RESOLUTION OF 15 MEV NOT UNFOLDED.
```

49 XI*1/2(1530) REAL PART OF POLE POSITION 4/75

```
REO        1531.6      0.4                LICHTENB  74       0 EXTRAP HABIBI73   4/75
RE-        1534.4      1.1                LICHTENB  74       -  EXTRAP HABIBI73  4/75
```

49 XI*1/2(1530) IMAGINARY PART OF POLE POSITION 4/75

```
IMO          4.45      0.35               LICHTENB  74       0 EXTRAP HABIBI73   4/75
IM-          3.9       1.75      3.9      LICHTENB  74       -  EXTRAP HABIBI73  4/75
```

49 XI*1/2(1530) PARTIAL DECAY MODES

```
                                                          DECAY MASSES
P1      XI*1/2(1530) INTO XI PI                         1321+ 139
        OTHER STRONG DECAYS ARE FORBIDDEN BY ENERGY CONSERVATION.
P2      XI*1/2(1530) INTO XI GAMMA                      1321+   0
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Data Card Listings

For notation, see key at front of Listings.

Baryons

Ξ(1530), Ξ(1630), Ξ(1680), Ξ(1820)

49 XI*1/2(1530) BRANCHING RATIOS (MEV)

R1 XI*1/2(1530) INTO (XI GAMMA)/TOTAL (P2) 1/76
R1 (0.04) OR LESS CL=.90 KALBFLEI 75 HBC - K-P AT 2.18 GEV 1/76

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REFERENCES FOR XI*1/2(1530)

BERTANZA 62 PRL 9 180 +BRISSON,CONNOLLY,GOLDBERG,GRAY,+(BNL,SYRA) IJ
PJERRCU 62 PRL 9 114 +PROWSE,SCHLEIN,SLATER,STORK,TICHO (UCLA) I
SCHLEIN 63 PRL 11 167 +CARMONY,PJERROU,SLATER,STORK,TICHO (UCLA)IJP
BADIER 64 DUBNA I 593 +DEMOULIN,GOLDBERG, + (EPOL,SACLAY,AMST) I
PJERROU 65 PRL 14 275 +SCHLEIN,SLATER,SMITH,STORK,TICHO (UCLA)

BERGE 66 PR 147 945 +EBERHARD,HUBBARD,MERRILL,B-SHAFER,+ (LRL) I
LONDON 66 PR 143 1034 +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+ (BNL,SYRA) IJ
MERRILL 66 UCRL-16455 THESIS D W MERRILL (LRL) JP

BADIER 72 NP B37 429 +BARRELET,CHARLTON,VIDEAU (EPOL)
BALTAY 72 PL 42B 129 +BRIDGEWATER,COOPER,GERSHWIN,+ (COLU+BING)
ALSO 73 NEVIS 199(THESIS) HABIBI (COLUMBIA)
BORENSTE 72 PR D5 1559 BORENSTEIN,DANBURG,KALBFLEISCH++ (BNL,MICH) I
KIRSCH 72 NP B40 349 SCHMIDT+CHANG,HEMINGWAY(BRAN,UMD,SYRA,TUFT) I

ROSS2 73 PURDUE CONF. 355 ROSS,LLOYD,RADOJICIC (OXFORD)
BERTHON 74 NC 21A 146 BERTHON,TRISTRAM,+ (CDEF+RHEL+SACL+STRB)
LICHTENB 74 PRD 10 3865 D B LICHTENBERG (INDIANA UNIVERSITY)
ALSO 74 PRIV. COMM. D B LICHTENBERG (INDIANA UNIVERSITY)

BELLEFO2 75 NC 28A 289 DE BELLEFON,BERTHON,BILLOIR+ (CDEF,SACL)
KALBFLEI 75 PRD 11 987 KALBFLEISCH,STRAND,CHAPMAN (BNL+MICH)
SIXEL 79 NP B159 125 +BOTTCHER,KLEIN+ (AACH+BERL+CERN+LOIC+VIEN)

PAPERS NOT REFERRED TO IN DATA CARDS

SHAFER 66 PR 142 883 BUTTON-SHAFER,LINDSEY,MURRAY,SMITH (LRL) JP
A SPIN-PARITY DETERMINATION.
HABIBI 73 NEVIS 199(THESIS) HABIBI (COLU)
HUNGERBU 74 PRD 10 2051 HUNGERBUHLER,MAJKA,+ (YALE,FNAL,BNL,PITT)
BRIEFEL 75 PRD 12 1859 +GOUREVITCH,KIRSCH+ (BRAN+UMD+SYRA+TUFT)
BRIEFEL 77 PRD 16 2706 +GOUREVITCH,CHANG+ (BRAN+UMD+SYRA+TUFT)

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Ξ(1630)

21 XI*1/2(1630, JP=) I=1/2

THIS EFFECT NEEDS CONFIRMATION.
BARTSCH 69 SEE A SMALL, BROAD ENHANCEMENT NEAR 1650 MEV - IT IS NOT CLEAR THAT IT IS THE SAME PHENOMENON AS BRIEFEL 77, WHO FIND CS=2.6+-0.9 MICROBARNS AT 2.87 GEV/C INCIDENT K- MOMENTUM.
BORENSTEIN 72 SEE NO EFFECT IN THIS REGION. THEY FIND CS<2 MICROBARNS AT 2.18 GEV/C.
ROSS 72 ARGUE THAT THE EFFECT THEY SEE IS NOT THE SAME AS THAT SEEN BY BRIEFEL 77 (WHOSE PRELIMINARY RESULTS WERE REPORTED IN BMST 70), AND FIND CS=2+-1 MICROBARNS AT 3.3 GEV/C.
BELLEFON 75 FIND A CS OF AROUND 10 MICROBARNS NEAR 2 GEV/C, BUT LESS THAN 3 MICROBARNS AROUND 2.3 GEV/C.

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21 XI*1/2(1630) MASS (MEV)

M 29 1606. 6. ROSS 72 HBC 0 K-P AT 3.1-3.7 3/72
M 34 1633. 12. BELLEFO2 75 HBC 0 K-P TO XI- K PI 11/75
M 31 1624. 3. BRIEFEL 77 HBC 0 K-P 2.87 GEV/C 1/78
M . . . .
M AVERAGE MEANINGLESS (SCALE FACTOR = 2.0)

------ --------- --------- --------- --------- --------- --------- --------

21 XI*1/2(1630) WIDTH (MEV)

W 29 21. 7. ROSS 72 HBC 0 XI-PI+ K*0(890) 3/72
W 34 40. 15. BELLEFO2 75 HBC 0 K-P TO XI- K PI 11/75
W F 31 (22.5) BRIEFEL 77 HBC 0 K-P 2.87 GEV/C 1/78
W F GOODNESS OF FIT INSENSITIVE TO VALUES BETWEEN 15 AND 30 MEV.
W F THE SIGNIFICANCE OF THE EFFECT IS CLAIMED TO BE ABOUT 3 STD. DEV.
W . . . .
W AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

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21 XI*1/2(1630) PARTIAL DECAY MODES

DECAY MASSES
P1 XI*1/2(1630) INTO XI PI 1321+ 139

SEEN IN K- P TO XI- PI+ KO AND XI- PIO K+.

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REFERENCES FOR XI*1/2(1630)

ROSS 72 PL 38B 177 ,BURAN,LLOYD,MULVEY,RADCJICIC (OXF) I
BELLEFO2 75 NC 28A 289 DE BELLEFON,BERTHON,BILLOIR+ (CDEF,SACL)
BRIEFEL 77 PRD 16 2706 +GOUREVITCH,CHANG+ (BRAN+UMD+SYRA+TUFT)
ALSO 70 DUKE CCNF. 317 BMST (BRANDEIS+MARYLAND+SYRACUSE+TUFTS)

PAPERS NOT REFERRED TO IN DATA CARDS

APSELL 69 PRL 23 884 + (BRANDEIS, MARYLAND, SYRACUSE, TUFTS)
SUPERSEDED BY BMST 70.
BARTSCH 69 PL 28B 439 + (AACHEN, BERLIN, CERN, LOIC, VIENNA)
KALBFLEI 70 DUKE CONF 331 G R KALBFLEISCH (BNL) I
SUMMARIZES EVIDENCE FOR ISOSPIN ONE-HALF.
BORENSTE 72 PR D5 1559 BORENSTEIN,DANBURG,KALBFLEISCH++ (BNL,MICH) I
SCHMIDT 73 PURDUE CONF. 363 SCHMIDT (BRANDEIS)
HUNGERBU 74 PRD 10 2051 HUNGERBUHLER,MAJKA,+ (YALE,FNAL,BNL,PITT)
BRIEFEL 75 PRD 12 1859 +GOUREVITCH,KIRSCH+ (BRAN+UMD+SYRA+TUFT)

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Ξ(1680)

5 XI*1/2(1680, JP=1/2-) I=1/2 S_{11}

SEEN BY DIONISI 78 AS A THRESHOLD ENHANCEMENT IN BOTH THE NEUTRAL AND NEGATIVELY CHARGED SIGMA KBAR MASS SPECTRA FROM THE REACTIONS K-P --> (SIGMA KBAR) K PI AT 4.2 GEV/C. THE DATA FROM THE SIGMA KBAR CHANNELS ALONE CANNOT DISTINGUISH BETWEEN A RESONANCE INTERPRETATION AND A LARGE SCATTERING LENGTH.
WEAKER EVIDENCE FOR AN ENHANCEMENT AT THE SAME MASS IS SEEN IN THE CORRESPONDING LAMBDA KBAR CHANNELS AND A COUPLED CHANNEL ANALYSIS YIELDS RESULTS CONSISTENT WITH A NEW XI*.
IN NEED OF CONFIRMATION. OMITTED FROM THE TABLES.

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5 XI*1/2(1680) MASS (MEV)

MO NEUTRAL CHARGE
MO F 175(1699.) (5.) DIONISI 78 HBC 0 K-P AT 4.2 GEV/C 3/79*
MO C 183(1684.) (5.) DIONISI 78 HBC 0 K-P AT 4.2 GEV/C 3/79*
MO F FROM FIT TO SIGMA+ K- SPECTRUM 3/79*
MO C FROM COUPLED CHANNEL ANALYSIS OF SIGMA+ K- AND LAMBDA KO SPECTRA 3/79*

M- NEGATIVE CHARGE
M- C 45(1694.) (6.) DIONISI 78 HBC - K-P AT 4.2 GEV/C 3/79*
M- C FROM COUPLED CHANNEL ANALYSIS OF SIGMAO K- AND LAMBDA K- SPECTRA 3/79*

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5 XI*1/2(1680) WIDTH (MEV)

WO NEUTRAL CHARGE
WO F 175 (44.) (23.) DIONISI 78 HBC 0 K-P AT 4.2 GEV/C 3/79*
WO C 183 (20.) (4.) DIONISI 78 HBC 0 K-P AT 4.2 GEV/C 3/79*
WO F FROM FIT TO SIGMA+ K- SPECTRUM 3/79*
WO C FROM COUPLED CHANNEL ANALYSIS OF SIGMA+ K- AND LAMBDA K- SPECTRA 3/79*

W- NEGATIVE CHARGE
W- C 45 (26.) (6.) DIONISI 78 HBC - K-P AT 4.2 GEV/C 3/79*
W- C FROM COUPLED CHANNEL ANALYSIS OF SIGMAO K- AND LAMBDA K- SPECTRA 3/79*

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5 XI*1/2(1680) PARTIAL DECAY MODES

DECAY MASSES
P1 XI*1/2(1680) INTO SIGMA KBAR 1192+ 497
P2 XI*1/2(1680) INTO LAMBDA KBAR 1115+ 497
P3 XI*1/2(1680) INTO XI PI 1314+ 134
P4 XI*1/2(1680) INTO XI*1/2(1530) PI 1533+ 134
P5 XI*1/2(1680) INTO XI PI PI (INCLUDING P4) 1314+ 134+ 134

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5 XI*1/2(1680) BRANCHING RATIOS

R1 XI*1/2(1680) INTO (SIGMA KBAR)/(LAMBDA KBAR) (P1)/(P2)
R1 Z (2.7) (0.9) DIONISI 78 HBC 0 K-P AT 4.2 GEV/C 3/79*
R1 N (3.1) (1.4) DIONISI 78 HBC - K-P AT 4.2 GEV/C 3/79*
R1 Z NEUTRAL CHARGE
R1 N NEGATIVE CHARGE

R2 XI*1/2(1680) INTO (XI PI)/(SIGMA KBAR) (P3)/(P1)
R2 (.09) OR LESS DIONISI 78 HBC 0 K-P AT 4.2 GEV/C 3/79*

R3 XI*1/2(1680) INTO (XI- PI+ PIO)/(SIGMA KBAR) (P5)/(P1)
R3 (.04) OR LESS DIONISI 78 HBC 0 K-P AT 4.2 GEV/C 3/79*

R4 XI*1/2(1680) INTO (XI- PI+ PI-)/(SIGMA KBAR) (P5)/(P1)
R4 (.03) OR LESS DIONISI 78 HBC - K-P AT 4.2 GEV/C 3/79*

R5 XI*1/2(1680) INTO (XI*(1530) PI)/(SIGMA KBAR) (P4)/(P1)
R5 (.06) OR LESS DIONISI 78 HBC - K-P AT 4.2 GEV/C 3/79*

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REFERENCES FOR XI*1/2(1680)

DIONISI 78 PL 80B 145 +DIAZ,ARMENTEROS+ (CERN+AMST+NIJM+OXF)I,JP

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Ξ(1820)

50 XI*1/2(1820, JP=3/2) I=1/2

WE LIST HERE EVERYTHING REPORTED IN THE MASS RANGE 1750-1875 MEV.
THE CLEAREST EVIDENCE FOR THIS STATE IS THAT OF GAY 76, WHO SEE AN 8 STD. DEV. ENHANCEMENT IN LAMBDA K-, AS WELL AS ENHANCEMENTS IN XI*(1680) PI, AND SIGMA KBAR. THE ENHANCEMENT OBSERVED BY GAY 76 IS NARROW (WIDTH 21 +- 7 MEV), IN CONTRAST TO RESULTS FROM EARLIER LESS SIGNIFICANT DATA WHERE WIDTHS OF UP TO 100 MEV HAVE BEEN REPORTED (SEE THE DATA CARD LISTINGS BELOW). GAY 76 OBSERVE NO SIGNAL IN THE XI PI CHANNEL. IT IS POSSIBLE THAT THE XI PI ENHANCEMENTS SEEN IN THIS MASS REGION BY SOME EXPERIMENTS AT LOWER MOMENTUM ARE AT LEAST PARTIALLY DUE TO THE XI*(1940), WITH A SHAPE DISTORTED BY THE MORE LIMITED AVAILABLE PHASE SPACE (SMITH 65). THE SITUATION IS FURTHER CONFUSED BY SOME EXPERIMENTS BEING FORCED TO ADD SEVERAL DIFFERENT CHANNELS TO OVERCOME POOR STATISTICS (CRENNELL 70, BADIER 71).
A SPIN PARITY ANALYSIS OF THE GAY 76 DATA BUT WITH MORE STATISTICS (TEODORO 78), FAVOURS J=3/2 BUT CANNOT MAKE A PARITY DISCRIMINATION.

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50 XI*1/2(1820) MASS (MEV)

M (1770.0) HALSTEINS 63 FBC -0 K-FR 3.5 GEV/C
M 30 1814.0 4.0 BADIER 65 HBC 0 LAMBDA KOBAR
M 29 1817.0 7.0 SMITH 1 65 HBC -0 LAMBDA KBAR
M 40 1830.0 10.0 ALITTI 69 HBC - LAM, SIG KBAR 9/69
M C 25 1830.0 10.0 CRENNELL 70 DBC -0 3.6, 3.9 GEV/C 10/70
M C FROM FIT TO INCLUSIVE XI PI, XI PI PI AND LAMBDA K- SPECTRA
M O (1826.0) (12.0) CRENNELL 70 DBC -0 3.6, 3.9 GEV/C 11/77
M C FROM FIT TO INCLUSIVE XI PI AND XI PI PI SPECTRA ONLY
M B 28 1762.0 8.0 BADIER 72 HBC -0 XI PI,XI2PI,K Y 10/71
M B 38 1838.0 5.0 BADIER 72 HBC -OXI PI,XI2PI,K Y 10/71
M B BADIER 72 ADDS ALL CHANNELS AND DIVIDES PEAK IN LOWER AND HIGHER
M B MASS REGIONS. THE DATA CAN ALSO BE FITTED WITH A SINGLE BREIT-
M B WIGNER OF MASS 1800 AND WIDTH 150 MEV.

Baryons
Ξ(1820)


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M    1  30 1821.        5.                ROSS1     73 HBC  -0 LAMBDA K-/KBARO   2/74
M    1  LESS SIGNIFICANT ENHANCEMENTS SEEN IN XI*(1530) PI (M=1825,W=100)
M    1  AND SIGMA KBAR (M=1810+-9,W=16+-11).
M          1807.       27.                DIBIANCA  75 DBC  -0 XI 2PI, XI* PI    1/76
M      130 1823.0       2.0               GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
M       74 1797.       19.                BRIEFEL   77 HBC   0 XI PI (2.87 K-P)  1/78
M       68 1829.        9.                BRIEFEL   77 HBC  -0 XI(1530) PI       1/78
M       39 1860.       14.                BRIEFEL   77 HBC  -  SIGMA- KOBAR      1/78
M       44 1870.        9.                BRIEFEL   77 HBC   0 LAMBDA KOBAR      1/78
M       57 1813.        4.                BRIEFEL   77 HBC  -  LAMBDA K-         1/78
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 3.2)
                      (SEE IDEOGRAM BELOW )
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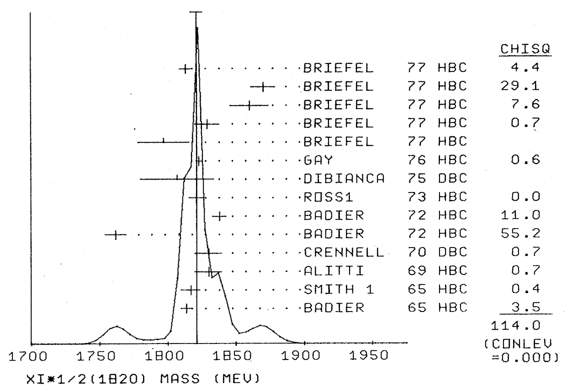


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                   50  XI*1/2(1820) WIDTH (MEV)

W           (80.0)  OR LESS             HALSTEINS 63 FBC  -0 K-FR 3.5 GEV/C
W           (12.0)   (4.0)              BADIER    65 HBC   0 LAMBDA KOBAR
W            30.0     7.0               SMITH 2   65 HBC  -0 LAMBDA KBAR
W            55.0    40.0     20.0      ALITTI    69 HBC  -  LAM, SIG KBAR     9/69
W  C        103.0    38.0     24.0      CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C   10/70
W   O       (48.0)  (36.0)   (19.0)     CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C   11/77
W  B         51.0    13.0               BADIER    72 HBC  -0 LOWER MASS       10/71
W  B         58.0    13.0               BADIER    72 HBC  -0 HIGHER MASS      10/71
W     1  30  12.      4.                ROSS1     73 HBC  -0 LAMBDA K-/KBARO   2/74
W            85.     58.                DIBIANCA  75 DBC  -0 XI 2PI, XI* PI    1/76
W       130  21.0     7.0               GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
W        74  99.     57.                BRIEFEL   77 HBC   0 XI PI (2.87 K-P)  1/78
W        68  52.     34.                BRIEFEL   77 HBC  -0 XI(1530) PI       1/78
W        39  72.     17.                BRIEFEL   77 HBC  -  SIGMA- KOBAR      1/78
W        44  44.     11.                BRIEFEL   77 HBC   0 LAMBDA KOBAR      1/78
W        57  26.     11.                BRIEFEL   77 HBC  -  LAMBDA K-         1/78
W  ***               SEE THE NOTES ACCOMPANYING THE MASSES QUOTED ABOVE.
W          . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 2.2)
                      (SEE IDEOGRAM BELOW )
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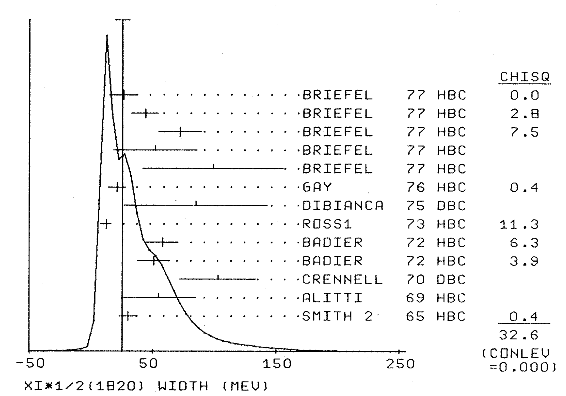


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                  50  XI*1/2(1820) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     XI*1/2(1820) INTO LAMBDA KBAR                    1115+ 497
P2     XI*1/2(1820) INTO XI PI                          1321+ 139
P3     XI*1/2(1820) INTO SIGMA KBAR                     1197+ 497
P4     XI*1/2(1820) INTO XI*1/2(1530) PI                1533+ 139
P5     XI*1/2(1820) INTO XI PI PI (EXCLUDING P4)        1321+ 139+ 139

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

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        P 1         P 2         P 3         P 4
 P 1 .4974+-.0812
 P 2   -.7282  .1889+-.0505
 P 3    .1061     -.4931  .1463+-.0469
 P 4   -.7972      .5122     -.4933  .1674+-.0620


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                  50  XI*1/2(1820) BRANCHING RATIOS

R1      XI*1/2(1820) INTO (LAMBDA KBAR)/TOTAL             (P1)
R1            0.30      0.15             ALITTI    69 HBC  -  K-P 3.9-5.0 GEV   9/69
R1          . . . . . . . . .
R1   FIT      0.497     0.081  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

R2      XI*1/2(1820) INTO (XI PI)/TOTAL                   (P2)
R2            0.10      0.10             ALITTI    69 HBC  -  K-P 3.9-5.0 GEV   9/69
R2          . . . . . . . . .
R2   FIT      0.189     0.050  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R21     XI*1/2(1820) INTO (XI PI)/(LAMBDA KBAR)           (P2)/(P1)
R21           0.20      0.20             BADIER    65 HBC   0 K-P AT 3 GEV      7/66
R21          (0.36) OR LESS  CL=.95      GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
R21         . . . . . . . . .
R21  FIT      0.38      0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

R22     XI*1/2(1820) INTO (XI PI)/(XI*1/2(1530) PI)       (P2)/(P4)
R22           1.5       0.6      0.4     APSELL    70 HBC   0 K-P AT 2.87 GEV   6/70
R22         . . . . . . . . .
R22  FIT      1.13      0.37   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      XI*1/2(1820) INTO (SIGMA KBAR)/TOTAL              (P3)
R3           (0.02) OR LESS              TRIPP     67 RVUE                      8/67
R3            0.30      0.15             ALITTI    69 HBC  -  K-P 3.9-5.0 GEV   9/69
R3          . . . . . . . . .
R3   FIT      0.146     0.047  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R31     XI*1/2(1820) INTO (SIGMA KBAR)/(LAMBDA KBAR)      (P3)/(P1)
R31           0.24      0.10             GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
R31         . . . . . . . . .
R31  FIT      0.29      0.10   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R4      XI*1/2(1820) INTO (XI*1/2(1530) PI)/TOTAL         (P4)
R4            0.30      0.15             ALITTI    69 HBC  -  K-P 3.9-5.0 GEV   9/69
R4   S       (0.25) OR LESS              DAUBER    69 HBC     K-P 2.7 BEV/C     9/69
R4   S   USES IN PART THE SAME DATA AS SMITH 65
R4          . . . . . . . . .
R4   FIT      0.167     0.062  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R41     XI*1/2(1820) INTO (XI*(1530) PI)/(LAM KBAR)       (P4)/(P1)
R41           0.26      0.13             SMITH 1   65 HBC  -0 K-P 2.45-2.70GEV
R41           1.0       0.3              GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
R41         . . . . . . . . .
R41 AVG       0.38      0.27    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
R41 STUDENT   0.35      0.14    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R41 FIT       0.34      0.17   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

R51     XI*1/2(1820) INTO (XI PI PI)/(LAMBDA KBAR)        (P5)/(P1)
R51          (0.1)  OR MORE              SMITH 1   65 HBC  -0 K-P 2.45-2.70GEV

R52     XI*1/2(1820) INTO (XI PI PI)/(XI*1/2(1530) PI)    (P5)/(P4)
R52 L        (0.3)     (0.5)             APSELL    70 HBC   0 K-P AT 2.87 GEV   6/70
R52 L    OR LESS. UPPER LIMIT FOR THE 3-BODY DECAY
R52          CONSISTENT WITH ZERO        GAY       76 HBC  -  K-P AT 4.2 GEV   11/77

R53     XI*1/2(1820) INTO XI PI PI (INCLUDING XI*(1530) PI)/(LAMBDA KBAR)
R53                                                       (P4+P5)/(P1)
R53  C       (0.14) OR LESS              BADIER    65 HBC   0 1 STD.DEV.LIMIT  11/77
R53  C   FOR THE DECAY MODE (XI- PI+ PI0) ONLY


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                          REFERENCES FOR XI*1/2(1820)

HALSTEIN 63 SIENA CONF 173     HALSTEINSLID,+ (BERGEN,CERN,EPOL,RHEL,LOUC) I
BADIER   65 PL 16 171          +DEMOULIN,GOLDBERG, +     (EPOL,SACLAY,AMST) I
SMITH 1  65 PRL 14 25          +LINDSEY,BUTTON-SHAFER,MURRAY          (LRL)IJP
SMITH 2  65 ATHENS CONF 251    G A SMITH, J S LINDSEY                  (LRL)
TRIPP    67 NP B3 10           + LEITH, +     (LRL,SLAC,CERN,HEIDEL,SACLAY)
   USES DATA OF SMITH 1.

ALITTI   69 PRL 22 79          +BARNES,FLAMINIO,METZGER, +  (BNL,SYRACUSE) I
DAUBER   69 PR 179 1262        +BERGE, HUBBARD, MERRILL, MULLER       (LRL)
APSELL   70 PRL 24 777         +     (BRANDEIS, MARYLAND, SYRACUSE, TUFTS) I
CRENNELL 70 PR 1D 847          +KARSHON, LAI, ONEALL, SCARR, SCHUMANN(BNL)
BADIER   72 NP B37 429         +BARRELET,CHARLTON,VIDEAU             (EPOL)
ROSS1    73 PURDUE CONF. 345   ROSS,LLOYD,RADOJICIC                (OXFORD)

DIBIANCA 75 NP B98 137         DIBIANCA,ENDORF                       (CARN)
GAY      76 PL 62B 477         +ARMENTEROS,BERGE,GAVILLET+(AMST+CERN+NIJM)IJ
BRIEFEL  77 PRD 16 2706        +GOUREVITCH,CHANG+      (BRAN+UMD+SYRA+TUFT)
   ALSO  70 DUKE CONF. 317     BMST        (BRANDEIS+MARYLAND+SYRACUSE+TUFTS)

                          PAPERS NOT REFERRED TO IN DATA CARDS

SMITH    64 PRL 13 61          +LINDSEY,MURRAY,BUTTON-SHAFER+         (LRL) IJP
MERRILL  68 PR 167 1202        D W MERRILL, J BUTTON-SHAFER            (LRL)
   WEAK EVIDENCE CONCERNING JP.
APSELL   69 PRL 23 884         +      (BRANDEIS, MARYLAND, SYRACUSE, TUFTS)
   SUPERSEDED BY BRIEFEL 77.
SCHMIDT  73 PURDUE CONF. 363   SCHMIDT                             (BRANDEIS)
BRIEFEL  75 PRD 12 1859        +GOUREVITCH,KIRSCH+     (BRAN+UMD+SYRA+TUFT)
TEODORO  78 PL 77B 451         +DIAZ,DIONISI,BLOKZIJL+(AMST+CERN+NIJM+CXF)  JP
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Data Card Listings

For notation, see key at front of Listings.

Baryons

Ξ(1940), Ξ(2030)

Ξ(1940)

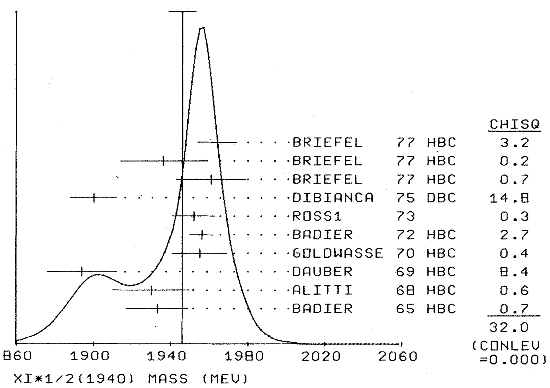
52 XI*1/2(1940, JP=) I=1/2

WE LIST UNDER XI(1940) EVERYTHING REPORTED IN THE MASS RANGE 1875-2000 MEV.

52 XI*1/2(1940) MASS (MEV)

M	35	1933.0	16.0	BADIER	65	HBC	0	XI- PI+	
M	27	1930.0	20.0	ALITTI	68	HBC	0	XI- PI+	11/68
M	66	1894.0	18.0	DAUBER	69	HBC	-	XI PI	11/68
M	21	1955.0	14.0	GOLDWASSE	70	HBC	-	XI PI	10/70
M	29	1956.0	6.0	BADIER	72	HBC		XI PI,XI2PI,K Y	10/71
M	25	1952.	11.	ROSS1	73			(XI PI)-	2/74
M		1900.	12.	DIBIANCA	75	DBC		XI PI	1/76
M	139	1961.	18.	BRIEFEL	77	HBC	0	XI-PI+(2.87 K-P)	1/78
M	44	1936.	22.	BRIEFEL	77	HBC	-	XIOPI-(2.87 K-P)	1/78
M	56	1964.	10.	BRIEFEL	77	HBC	-0	XI(1530) PI	1/78

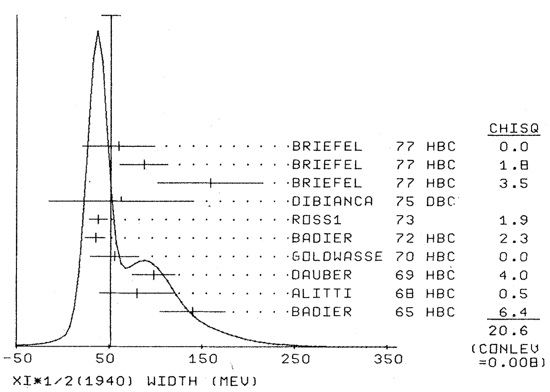
M . . . .
M AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)
(SEE IDEOGRAM BELOW)



52 XI*1/2(1940) WIDTH (MEV)

W	35	140.0	35.0	BADIER	65	HBC	0	XI- PI+	
W	27	80.0	40.0	ALITTI	68	HBC	0	XI- PI+	11/68
W	66	98.0	23.0	DAUBER	69	HBC	-	XI PI	11/68
W	21	56.0	26.0	GOLDWASSE	70	HBC	-	XI PI	10/70
W	29	35.0	11.0	BADIER	72	HBC		XI PI,XI2PI,K Y	10/71
W		38.	10.	ROSS1	73			(XI PI)-	2/74
W		63.	78.	DIBIANCA	75	DBC		XI PI	1/76
W	139	159.	57.	BRIEFEL	77	HBC	0	XI-PI+(2.87 K-P)	1/78
W	44	87.	26.	BRIEFEL	77	HBC	-	XIOPI-(2.87 K-P)	1/78
W	56	60.	39.	BRIEFEL	77	HBC	-0	XI(1530) PI	1/78

W . . . .
W AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)
(SEE IDEOGRAM BELOW)



52 XI*1/2(1940) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI*1/2(1940) INTO XI PI	1321+ 139
P2	XI*1/2(1940) INTO XI*(1530) PI	1533+ 139
P3	XI*1/2(1940) INTO XI PI PI (EXCLUDING P2)	1321+ 139+ 139
P4	XI*1/2(1940) INTO XIO PI-	1314+ 139
P5	XI*1/2(1940) INTO XI- PIO	1321+ 134

52 XI*1/2(1940) BRANCHING RATIOS

THE XI(1940) IS SEEN MAINLY IN XI PI AND SOME IN XI(1530) PI. IT HAS BEEN LOOKED FOR IN OTHER CHANNELS BUT NOT SEEN.

R1 XI*1/2(1940) INTO (XI PI)/(XI*1/2(1530) PI) (P1)/(P2)
R1 2.8 0.7 0.6 APSELL 70 HBC 0 6/70

R2 XI*1/2(1940) INTO (XI PI PI)/(XI*1/2(1530) PI) (P3)/(P2)
R2 0.0 0.3 APSELL 70 HBC 0 6/70

R3 XI*1/2(1940) INTO (XIO PI-)/(XI- PIO) (P4)/(P5) 2/74
R3 1 25 2.6 6. 1.6 ROSS1 73 (XI PI)- 2/74
R3 1 THIS BR IS 2.0(0.5) FOR AN I=1/2(I=3/2) XI*(1940). 2/74

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REFERENCES FOR XI*1/2(1940)

BADIER 65 PL 16 171 +DEMOULIN,GOLDBERG, + (EPOL,SACLAY,AMST) I
ALITTI 68 PRL 21 1119 +FLAMINIO,METZGER,RADOJICIC,+(BNL,SYRACUSE) I
DAUBER 69 PR 179 1262 +BERGE, HUBBARD, MERRILL, MULLER (LRL) I
APSELL 70 PRL 24 777 + (BRANDEIS, MARYLAND, SYRACUSE, TUFTS) I
GOLDWASS 70 PR 1D 1960 E L GOLDWASSER, P F SCHULTZ (ILLINOIS)
BADIER 72 NP B37,429 +BARRELET,CHARLTON,VIDEAU (EPOL)
ROSS1 73 PURDUE CONF. 345 ROSS,LLOYD,RADOJICIC (OXFORD)

DIBIANCA 75 NP B98 137 DIBIANCA,ENDORF (CARN)
BRIEFEL 77 PRD 16 2706 +GOUREVITCH,CHANG+ (BRAN+UMD+SYRA+TUFT)
ALSO 70 DUKE CONF. 317 BMST (BRANDEIS+MARYLAND+SYRACUSE+TUFTS)

PAPERS NOT REFERRED TO IN DATA CARDS

APSELL 69 PRL 23 884 + (BRANDEIS, MARYLAND, SYRACUSE, TUFTS)
SUPERSEDED BY BMST 70.
SCHMIDT 73 PURDUE CONF. 363 SCHMIDT (BRANDEIS)
BRIEFEL 75 PRD 12 1859 +GOUREVITCH,KIRSCH+ (BRAN+UMD+SYRA+TUFT)

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Ξ(2030)

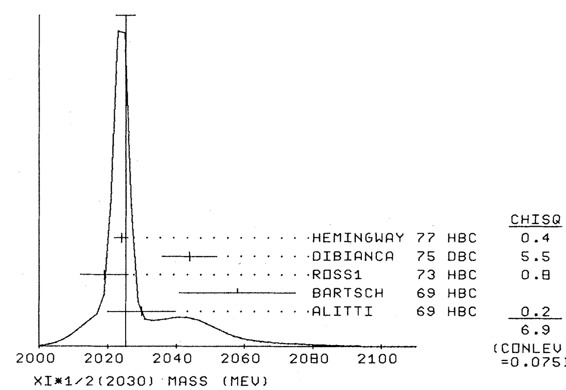
68 XI*1/2(2030, JP=5/2 OR GREATER) I=1/2

THE EVIDENCE FOR THIS STATE HAS BEEN MUCH IMPROVED BY HEMINGWAY 77, WHO SEE AN 8 STD. DEV. ENHANCEMENT IN SIGMA KBAR AND A WEAKER COUPLING TO LAMBDA KBAR. ALITTI 68 AND HEMINGWAY 77 OBSERVE NO SIGNALS IN THE XI PI PI (OR XI*(1530) PI) CHANNEL, IN CONTRAST TO DIBIANCA 75. THE DECAY INTO LAMBDA/SIGMA KBAR PI REPORTED BY BARTSCH 69 IS ALSO NOT CONFIRMED BY HEMINGWAY 77.
A MOMENTS ANALYSIS OF THE HEMINGWAY 77 DATA INDICATES THAT THE SPIN IS GREATER THAN OR EQUAL TO 5/2 AT A LEVEL OF 3 STD. DEVIATIONS.

68 XI*1/2(2030) MASS (MEV)

M	42	2030.0	10.0	ALITTI	69	HBC	-	K-P 3.9-5 BEV/C	9/69
M	40	2C58.0	17.0	BARTSCH	69	HBC	-0	K-P 10 GEV/C	9/69
M	15	2019.	7.	ROSS1	73	HBC	-0	SIGMA KBAR	2/74
M		2044.	8.	DIBIANCA	75	DBC	-0	XI 2PI, XI* PI	1/76
M	200	2024.	2.	HEMINGWAY	77	HBC	-	K-P AT 4.2 GEV	11/77

M . . . .
M AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)
(SEE IDEOGRAM BELOW)



68 XI*1/2(2030) WIDTH (MEV)

W		45.0	40.0	20.0	ALITTI	69	HBC	-	K-P 3.9-5 BEV/C	9/69
W		57.0	30.0		BARTSCH	69	HBC	-0	K-P 10 GEV/C	9/69
W	15	33.	17.		ROSS1	73	HBC	-0	SIGMA KBAR	2/74
W		60.	24.		DIBIANCA	75	DBC	-0	XI 2PI, XI* PI	1/76
W	200	16.	5.		HEMINGWAY	77	HBC	-	K-P AT 4.2 GEV	11/77

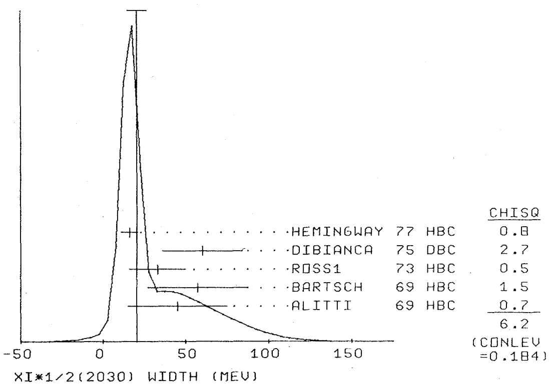
W . . . .
W AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)
(SEE IDEOGRAM BELOW)

Baryons

Ξ(2030), Ξ(2120), Ξ(2250), Ξ(2370)

Data Card Listings

For notation, see key at front of Listings.



68 XI*1/2(2030) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI*1/2(2030) INTO XI PI	1321+ 139
P2	XI*1/2(2030) INTO LAMBDA KBAR	1115+ 497
P3	XI*1/2(2030) INTO SIGMA KBAR	1197+ 497
P4	XI*1/2(2030) INTO XI*1/2(1530) PI	1533+ 139
P5	XI*1/2(2030) INTO XI PI PI (EXCLUDING P4)	1321+ 139+ 139
P6	XI*1/2(2030) INTO LAMBDA KBAR PI	1115+ 497+ 139
P7	XI*1/2(2030) INTO SIGMA KBAR PI	1189+ 497+ 139

68 XI*1/2(2030) BRANCHING RATIOS

R1 XI*1/2(2030) INTO (XI PI)/(MODES P1 TO P4) (P1)/(P1+P2+P3+P4)
R1 (0.30) OR LESS ALITTI 69 HBC - 1 STD DEV LIMIT 9/69

R11 XI*1/2(2030) INTO (XI PI)/(SIGMA KBAR) (P1)/(P3)
R11 (0.19) OR LESS CL=.95 HEMINGWAY 77 HBC - K-P AT 4.2 GEV 11/77

R2 XI*1/2(2030) INTO (LAM KBAR)/(MODES P1 TO P4) (P2)/(P1+P2+P3+P4)
R2 0.25 0.15 ALITTI 69 HBC - K-P 3.9-5 BEV/C 9/69

R21 XI*1/2(2030) INTO (LAMBDA KBAR)/(SIGMA KBAR) (P2)/(P3)
R21 0.22 0.09 HEMINGWAY 77 HBC - K-P AT 4.2 GEV 11/77

R3 XI*1/2(2030) INTO (SIG KBAR)/(MODES P1 TO P4) (P3)/(P1+P2+P3+P4)
R3 0.75 0.20 ALITTI 69 HBC - K-P 3.9-5 BEV/C 9/69

R4 XI*1/2(2030) INTO (XI* PI)/(MODES P1 TO P4) (P4)/(P1+P2+P3+P4)
R4 (0.15) OR LESS ALITTI 69 HBC - 1 STD DEV LIMIT 9/69

R41 XI*1/2(2030) INTO (XI PI PI INCLUDING XI* PI)/(SIGMA KBAR)
R41 (P4+P5)/(P3)
R41 C (0.11) OR LESS CL=.95 HEMINGWAY 77 HBC - K-P AT 4.2 GEV 11/77
R41 C FOR THE DECAY MODE (XI- PI+ PI-) ONLY

R6 XI*1/2(2030) INTO LAMBDA KBAR PI (P6)
R6 SEEN BARTSCH 69 HBC K-P AT 10 GEV 11/77

R61 XI*1/2(2030) INTO (LAMBDA KBAR PI)/(SIGMA KBAR) (P6)/(P3)
R61 (0.32) OR LESS CL=.95 HEMINGWAY 77 HBC - K-P AT 4.2 GEV 11/77

R7 XI*1/2(2030) INTO SIGMA KBAR PI (P7)
R7 SEEN BARTSCH 69 HBC K-P AT 10 GEV 11/77

R71 XI*1/2(2030) INTO (SIGMA KBAR PI)/(SIGMA KBAR) (P7)/(P3)
R71 C (0.04) OR LESS CL=.95 HEMINGWAY 77 HBC - K-P AT 4.2 GEV 11/77
R71 C FOR THE DECAY MODE (SIGMA+- K- PI-+) ONLY

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REFERENCES FOR XI*1/2(2030)

ALITTI 69 PRL 22 79 +BARNES,FLAMINIO,METZGER, + (BNL,SYRACUSE) I
BARTSCH 69 PL 28B 439 + (AACHEN, BERLIN, CERN, LOIC, VIENNA)
ROSSI 73 PURDUE CONF. 345 ROSS,LLOYD,RADOJICIC (OXFORD)

DIBIANCA 75 NP B98 137 DIBIANCA,ENDORF (CARN)
HEMINGWA 77 PL 68B 197 HEMINGWAY,ARMENTEROS+ (AMST+CERN+NIJM+OXF) IJ
ALSO 76 PL 62B 477 GAY,ARMENTEROS,BERGE+ (AMST+CERN+NIJM)

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Ξ(2120)

103 XI*1/2(2120, JP=) I=1/2

THIS EFFECT IS REPORTED IN GAY 76 AS A FOUR STANDARD DEVIATION ENHANCEMENT IN LAMBDA K-. AN ANALYSIS OF THE SAME DATA BY HEMINGWAY 77, BUT WITH ADDITIONAL STATISTICS, POINTS OUT THAT THE SIGNIFICANCE OF THE ENHANCEMENT IS GREATLY REDUCED IF A RESTRICTIVE FOUR-MOMENTUM CUT (U-CUT) IS MADE. THIS SUGGESTS AN ANOMALOUS PRODUCTION MECHANISM IF THE STATE IS GENUINE. CHLIAPNIKOV 79 REPORT A BUMP OF 18 EVENTS AT 2137 MEV IN AN INCLUSIVE ANTI-LAMBDA K+ SPECTRUM FROM K+P INTERACTIONS AT 32 GEV/C. THE K+ ARE NOT UNIQUELY IDENTIFIED. BUMPS WITH LOWER NUMBERS OF EVENTS ARE ALSO REPORTED AT 2240, 2830, AND 2540 MEV.
IN NEED OF CONFIRMATION, OMITTED FROM TABLES.

103 XI*1/2(2120) MASS (MEV)

M 2123.0 7.0 GAY 76 HBC - K- P AT 4.2 GEV 2/77
M 18(2137.) (4.) CHLIAPNIK 79 HBC + ANTI-LAMBDA K+ 1/80*

103 XI*1/2(2120) WIDTH (MEV)

W 25.0 12.0 GAY 76 HBC - K- P AT 4.2 GEV 2/77
W 18 (20.) OR LESS CHLIAPNIK 79 HBC + ANTI-LAMBDA K+ 1/80*

103 XI*1/2(2120) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI*1/2(2120) INTO LAMBDA KBAR	1115+ 497

103 XI*1/2(2120) BRANCHING RATIOS

R1 XI*1/2(2120) INTO LAMBDA KBAR (P1)
R1 SEEN GAY 76 HBC - K- P AT 4.2 GEV 2/77

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REFERENCES FOR XI*1/2(2120)

GAY 76 PL 62B 477 +ARMENTEROS,BERGE,GAVILLET+(AMST+CERN+NIJM)I
HEMINGWA 77 PL 68B 197 HEMINGWAY,ARMENTEROS+ (AMST+CERN+NIJM+CXF)
CHLIAPNI 79 NP B158 253 CHLIAPNIKOV,GERDYUKOV+ (SERP+BELG+MONS)

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Ξ(2250)

22 XI*1/2(2250, JP=)

THE EVIDENCE FOR THIS STATE IS WEAK. BARTSCH 69 SEE A BUMP OF NOT MUCH STATISTICAL SIGNIFICANCE IN LAMBDA-KBAR-PI, SIGMA-KBAR-PI, AND XI-PI-PI MASS SPECTRA. GOLDWASSER 70 SEE A NARROWER BUMP IN XI-PI-PI AT A HIGHER MASS. PERHAPS THEY ARE THE SAME STATE, PERHAPS THEY ARE NOT, BUT SEE ALSO MORRIS 75.

22 XI*1/2(2250) MASS (MEV)

M 35 2244.0 52.0 BARTSCH 69 HBC K-P 10 GEV/C 9/69
M 18 2295.0 15.0 GOLDWASSE 70 HBC - K-P 5.5 GEV/C 10/70
M . . . .
M AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

22 XI*1/2(2250) WIDTH (MEV)

W 130.0 80.0 BARTSCH 69 HBC 9/69
W LESS THAN 30.0 GOLDWASSE 70 HBC - K-P 5.5 GEV/C 10/70

22 XI*1/2(2250) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI*1/2(2250) INTO XI PI PI	1321+ 139+ 139
P2	XI*1/2(2250) INTO LAMBDA KBAR PI	1115+ 497+ 139
P3	XI*1/2(2250) INTO SIGMA KBAR PI	1197+ 497+ 139

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REFERENCES FOR XI*1/2(2250)

BARTSCH 69 PL 28B 439 + (AACHEN, BERLIN, CERN, LOIC, VIENNA)
GOLDWASS 70 PR D1 1960 E L GOLDWASSER, P F SCHULTZ (ILLINOIS)

PAPERS NOT REFERRED TO IN DATA CARDS

MORRIS 75 ANL-HEP-CP-75-58 MORRIS,OH,PARKER,SMITH,WHITMORE (MSU)

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Ξ(2370)

131 XI*1/2(2370, JP=) I=1/2

SEEN BY AMIRZADEH2 79 IN THE CHARGED AND NEUTRAL LAMBDA/SIGMA KBAR PI MASS SPECTRA FROM THE REACTIONS K-P --> XI* K AND XI* K PI AT 8.25 GEV/C. A SMALL EFFECT AT THE SAME MASS IS ALSO OBSERVED IN THE OMEGA- K MASS SPECTRUM.
IN NEED OF CONFIRMATION, OMITTED FROM TABLES.

131 XI*1/2(2370) MASS (MEV)

M 94 2373. 8. AMIRZAD2 79 HBC -0 K-P AT 8.25 GEV 1/80*

131 XI*1/2(2370) WIDTH (MEV)

W 94 80. 25. AMIRZAD2 79 HBC -0 K-P AT 8.25 GEV 1/80*

131 XI*1/2(2370) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI*1/2(2370) INTO LAMBDA KBAR PI	1115+ 497+ 139
P2	XI*1/2(2370) INTO SIGMA KBAR PI	1197+ 497+ 139
P3	XI*1/2(2370) INTO OMEGA- K	1672+ 497

131 XI*1/2(2370) BRANCHING RATIOS

R1 XI*1/2(2370) INTO LAMBDA KBAR PI (P1)
R1 SEEN AMIRZAD2 79 HBC -0 K-P AT 8.25 GEV 1/80*

R2 XI*1/2(2370) INTO SIGMA KBAR PI (P2)
R2 SEEN AMIRZAD2 79 HBC -0 K-P AT 8.25 GEV 1/80*

R3 XI*1/2(2370) INTO OMEGA- K (P3)
R3 SEEN AMIRZAD2 79 HBC - K-P AT 8.25 GEV 1/80*

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Data Card Listings

For notation, see key at front of Listings.

Baryons

$\Xi(2500)$, Ω^-, Λ_c^+, $\Sigma_c(2430)$, DIBARYONS

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                          REFERENCES FOR XI*1/2(2370)

AMIRZAD2 79  CERN/EP 79-130   AMIRZADEH+        (BIRM+CERN+GLAS+MSU+LPNP)I

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$\Xi(2500)$

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                99  XI*1/2(2500, JP=    ) I=1/2

                IT IS QUITE POSSIBLE THAT THE REASON THE EXPERIMENTS
                DISAGREE ABOUT THE MASS AND WIDTH IS THAT THEY ARE
                SEEING DIFFERENT XI*S.  FOR NOW, HOWEVER, WE GROUP
   THEM TOGETHER.

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                99  XI*1/2(2500) MASS (MEV)

M       30 2430.0     20.0              ALITTI    69 HBC  -  K-P 4.6-5 GEV/C    9/69
M       45 2500.0     10.0              BARTSCH   69 HBC  -0 K-P 10 GEV/C       9/69
M          2392.      27.               DIBIANCA  75 DBC     XI 2PI             1/76
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 3.2)

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                99  XI*1/2(2500) WIDTH (MEV)

W          150.0      60.0     40.0     ALITTI    69 HBC  -                     9/69
W           59.0      27.0              BARTSCH   69 HBC  -0                    9/69
W           75.       69.               DIBIANCA  75 DBC     XI 2PI             1/76
W          . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

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                99  XI*1/2(2500) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      XI*1/2(2500) INTO XI PI                         1321+ 139
P2      XI*1/2(2500) INTO LAMBDA KBAR                   1115+ 497
P3      XI*1/2(2500) INTO SIGMA KBAR                    1197+ 497
P4      XI*1/2(2500) INTO XI*1/2(1530) PI               1533+ 139
P5      XI*1/2(2500) INTO LAMBDA (OR SIGMA) KBAR PI     1115+ 497+ 139
P6      XI*1/2(2500) INTO XI PI PI                      1321+ 139+ 139

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                99  XI*1/2(2500) BRANCHING RATIOS

R1      XI*1/2(2500) INTO (XI PI)/(MODES P1 THRU P4)      (P1)/(P1+P2+P3+P4)
R1           (0.5)  OR LESS             ALITTI    69 HBC    1 STD DEV LIMIT     9/69

R2      XI*1/2(2500) INTO (LAM KBAR)/(MODES P1 THRU P4)   (P2)/(P1+P2+P3+P4)
R2            0.5      0.2              ALITTI    69 HBC  -                     9/69

R3      XI*1/2(2500) INTO (SIG KBAR)/(MODES P1 THRU P4)   (P3)/(P1+P2+P3+P4)
R3            0.5      0.2              ALITTI    69 HBC  -                     9/69

R4      XI*1/2(2500) INTO (XI* PI)/(MODES P1 THRU P4)     (P4)/(P1+P2+P3+P4)
R4           (0.2)  OR LESS             ALITTI    69 HBC    1 STD DEV LIMIT     9/69

R5      XI*1/2(2500) INTO (LAMBDA (OR SIGMA) KBAR PI)/TOTAL
R5                                                        (P5)
R5           SEEN                       BARTSCH   69 HBC  -0                    9/69

R6      XI*1/2(2500) INTO (XI PI PI)/TOTAL                (P6)
R6           SEEN                       BARTSCH   69 HBC  -0                    9/69

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                          REFERENCES FOR XI*1/2(2500)

ALITTI   69 PRL 22 79        +BARNES,FLAMINIO,METZGER, +  (BNL,SYRACUSE) I
BARTSCH  69 PL 28B 439       +       (AACHEN, BERLIN, CERN, LOIC, VIENNA)

DIBIANCA 75 NP B98 137       DIBIANCA,ENDORF                        (CARN)

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S=−3 I=0 HYPERON STATE (Ω)

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Ω^-

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                24  OMEGA-(1675, JP=3/2+) I=0
                SEE STABLE PARTICLE DATA CARD LISTINGS

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CHARMED BARYONS

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Λ_c^+

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                33  LAMBDA/C+(2260, JP=  )
                SEE STABLE PARTICLE DATA CARD LISTINGS

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$\Sigma_c(2430)$

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                104  SIGMA/C(2430, JP=  )
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                104  SIGMA/C MASS

M       1 2426.       12.              CAZZOLI   75 HBC  ++ LAMBDA/C+ PI+       3/77
M    K  9(2500.)                       KNAPP     76 SPEC 0  ANTILAMBDA/C-PI+    3/77
M       1(2439.)   OR MORE             BARISH    77 DBC  ++ LAMBDA/C+ PI+       3/77
M    K  KNAPP 76 MAY NOT BE THE SAME STATE AS CAZZOLI 75.  DERUJULA 75          3/77
M    K  PREDICT TWO SIGMA/C STATES AROUND 2.4-2.5 GEV.  THIS COULD BE BOTH.     3/77

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                104  (SIGMA/C)-(LAMBDA/C+) MASS DIFFERENCE  (MEV)

D     1 6.5  168.       3.             BALTAY    79 HLBC ++ LAMBDA/C+ PI+      12/79*
D     1  8 EVENTS WITH A BACKGROUND OF 1.5 IDENTIFIED AS                       12/79*
D     1  NU+NE-->(MU-)+(SIGMA/C++)+X, (SIGMA/C++)-->(LAMBDA/C+)+(PI+),         12/79*
D     1  (LAMBDA/C+)-->LAMBDA+(PI+)                                            12/79*

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                104  SIGMA/C(2430) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      SIGMA/C(2430) INTO LAMBDA/C+ PI              2273+ 139

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                       REFERENCES FOR SIGMA/C(2430)

CAZZOLI  75 PRL 34 1125      +CNOPS,CONNOLY,LOUTTIT,MURTAGH+        (BNL)
KNAPP    76 PRL 37 882       +LEE,LEUNG,SMITH +      (COLU+HAWA+ILL+FNAL)

BARISH   77 PR D15 1         +DERRICK,DOMBECK,MUSGRAVE +       (ANL+PURD)
BALTAY   79 PRL 26 1721      +CAROUMBALIS,FRENCH,HIBBS,HYLTON+(COLU+BNL)I

                             THEORY AND REVIEW

DERUJULA 75 PR D12 147       +GEORGI,GLASHOW                       (HARV)
LEE      77 PR D15 157       +QUIGG,ROSNER                         (FNAL)

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Dibaryon States

Dibaryon resonances have been predicted theoretically[1-4] and claimed experimentally, but although considerable evidence for them has been published, their existence remains controversial. Problems with the pp data have been pointed out by Bugg.[5] Either the $\Delta(\sigma_L)$ data and elastic data at 1 and 1.1 GeV/c are inconsistent, or accepted ideas about the mechanism of the inelastic channels are wrong.

Most significant evidence is included in the Listings, but there may be omissions, especially in earlier work. We have not included evidence on nuclear properties, hypernuclei, d*'s, or Δ's bound within the deuteron — though these may be related to effects observed in the search for dibaryon resonances. We have also omitted most data on low energy $\pi^+ d \to pp$. There is a large amount of literature on this reaction which we did not have time to review adequately. Most of these experiments are addressed to the question of whether there is a resonance associated with the NΔ threshold.

The Listings are grouped by strangeness.

References

1. R. J. Oakes, Phys. Rev. 131, 2239 (1963).
2. R. Dyson and N. Xuong, Phys. Rev. Lett. 13, 815 (1964).

Baryons

DIBARYONS

Data Card Listings

For notation, see key at front of Listings.

3. R. L. Jaffe, Phys. Rev. Lett. 38, 195 (1977).

4. J. J. de Swart, Nijmigen preprint THEF-NYM-79-16.

5. D. V. Bugg, J. Phys. G5, 1349 (1979).


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DIBARYONS

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S=0 →

106 BARYON NUMBER 2, STRANGENESS 0 STATES

EXPERIMENTS USING THE POLARIZED PROTON BEAM AND TARGET AT ARGCNNE HAVE SHOWN BROAD STRUCTURES IN THE DIPROTON SYSTEM. THE DATA SHOW A SIGNIFICANT DIP IN THE PP TOTAL CROSS SECTION DIFFERENCE BETWEEN ANTI-PARALLEL AND PARALLEL LONGITUDINALLY POLARIZED STATES. THIS DIP IS DUE TO A STRUCTURE IN THE PARALLEL CROSS SECTION WHICH DOES NOT APPEAR IN THE ANTI-PARALLEL CROSS SECTION. FURTHER EVIDENCE IS THE STRUCTURE IN THE ENERGY DEPENDENCE OF THE PP ELASTIC SCATTERING LEGENDRE COEFFICIENTS IN PURE SPIN STATES. THESE EFFECTS HAVE BEEN INTERPRETED (AUER 77, HIDAKA 77) AS EVIDENCE FOR A 3F3 STATE AT 2260 MEV (2S+1,L,J NOTATION). A FORWARD DISPERSION RELATION ANALYSIS (GREIN 77) OF THE ARGONNE DATA FINDS A SPIN SINGLET STATE AT 2390 MEV AND A SPIN TRIPLET STATE AT 2320 MEV, WITH WIDTHS OF ABOUT 100 MEV AND 290 MEV, RESPECTIVELY. (THE DISPERSION RELATION ANALYSIS CANNOT DETERMINE J). A PARTIAL WAVE ANALYSIS (HOSHIZAKI 77) OF ARGONNE AND OTHER DATA FAVORS A 3F3 RESONANT STATE AT 2260 MEV, WITH A WIDTH BETWEEN 100 MEV AND 250 MEV. AUER2 78 PRESENT AN ANALYSIS OF THE SPIN-SPIN CORRELATION PARAMETER CLL=C(L,L;0,0) AND FIND A POSSIBLE 1G4 RESONANCE AT 2500 MEV AN A 1D2 AT 2140, IN ADDITION TO THE 3F3 AT 2260.

MINAMI 78 HAS PRESENTED CRITICISM OF THE ANALYSIS OF BOTH HIDAKA 77 AND HOSHIZAKI 77, AND SUGGESTS THE OBSERVED EFFECTS ARE CONSISTENT WITH THE ABSENCE OF A RESONANCE.

ADDITIONAL EVIDENCE FOR THE EXISTENCE OF A DIBARYON RESONANCE IN THE 2350 MEV REGION COMES FROM A PHOTODISINTEGRATION EXPERIMENT (KAMAE 77 AND IKEDA 79), WHERE AN ANOMALY IN THE POLARIZATION IS CONSISTENT WITH AN I=0, J=3 STATE.

UEDA 78 SUGGESTS THE 3F3 STATE IS A (PI N N) SYSTEM WITH THE PI N SYSTEMS IN THE DELTA33 RESONANCE.

MACGREGOR 79 RELATES THE PROPOSED RESONANCES AT 2140, 2260, AND 2430 TO ROTATIONAL LEVELS OF A VIRTUAL P-P-PI(2020) BOUND STATE. OHBA 79 DISCUSSES A RELATION BETWEEN THE PROPOSED 2260 RESCNANCE AND THE A1-Z EXHANGE DEGENERACY.

BUGG 79 POINTS OUT AN INCONSISTENCY BETWEEN THE LONGITUDINALLY POLARIZED CROSS SECTION DATA AND THE REAL PART OF THE CORRESPONDING FORWARD AMPLITUDE BELOW THE REGION OF THE RESONANCES CLAIMED BY THE ARGONNE GROUP. WANTANBE 79 CALCULATES LARGER-THAN-EXPECTED CORRECTION FRCM COULOMB-NUCLEAR INTERFERENCE TO PURE SPIN STATE CROSS SECTICNS.

IN SPITE OF THE PROGRESS MADE BY RECENT WORK, MORE EXPERIMENTAL EVIDENCE IS NEEDED BEFORE THE EXISTENCE OF A TWO-NUCLEON RESONANCE CAN BE CONSIDERED CONFIRMED. IT IS UNLIKELY THAT THE DIPROTON(S) CAN BE FIRMLY ESTABLISHED UNTIL MUCH MORE INFORMATION ON ANGULAR DISTRIBUTIONS WITH POLARIZED BEAM AND TARGET IS AVAILABLE.

THE GENEVA GROUP HAS RECENTLY MADE ACCURATE MEASURMENTS, BUT THEY ARE NOT YET READY TO PUBLISH THEIR RESULTS. PRELIMINARY RESULTS PRESENTED AT THE 1979 CONFERENCE ON HIGH ENERGY PHYSICS AND NUCLEAR STRUCTURE (VANCOUVER) MAY DISAGREE WITH THE C(L,L;0,0) MEASUREMENTS FROM ARGONNE.

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106 B=2, S=0 STATES - CROSS SECTICN

THIS SECTION WE USE THE FOLLOWING ABBREVIATIONS FOR MEASURED QUANTITIES.

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LP        THE ENERGY DEPENDENCE OF THE P P TOTAL CROSS SECTION
          DIFFERENCE BETWEEN ANTI-PARRALLEL AND PARALLEL
          LONGITUDNALLY POLARIZED SPIN STATES.
TP        THE ENERGY DEPENDENCE OF THE P P TOTAL CROSS SECTION
          DIFFERENCE BETWEEN ANTI-PARRALLEL AND PARALLEL
          TRANSVERSLEY POLARIZED SPIN STATES.
LEG       THE ENERGY DEPENDENCE OF THE LEGENDRE COEFFICIENTS FOR
          P P ELASTIC SCATTERING IN PURE SPIN STATES.
CLL       THE CORRELATION PARAMETER C(L,L;0,0) FOR P P SCATTERING
PWA       PARTIAL WAVE ANALYSIS FOR P P SCATTERING.
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CS D       NOT SEEN                 DEBOER     75 CNTR  TP           10/77
CS C       SEEN                     AUER       77 CNTR  LP           10/77
CS E       SEEN                     HIDAKA     77 CNTR  LP,LEG        2/78
CS         SEEN                     AUER1      78 CNTR  LP            1/80*
CS         SEEN                     AUER2      78 CNTR  CLL           1/80*
CS B       POSSIBLY SEEN            BIEGERT    78 CNTR  TP            1/80*
CS R       NOT SEEN                 BRYAN      78 CNTR  PWA          12/79*
CS O       SEEN                     HOSHIZAKI  78 CNTR  PWA           3/79*
CS O       SEEN                     HOSHIZAKI  79 CNTR  PWA           3/79*
CS I       SEEN                     IKEDA      79 CNTR  GAMMA D       1/80*
CS D     DEBOER 75 STUDY LP AT 2,3,4 AND 6 GEV/C AT ARGONNE.       G
CS C     AUER 77 STUDY LP FROM 1 TO 2.5 . THEY OBSERVE A DIP AT 1.5 GEV/C  G
CS E     HIDAKA 77 USE DATA FROM THE SAME EXPERIMENT AS AUER 77.     10/77
CS E       THEY FAVOR S=1, L=3, J=3 QUANTUM NUMBERS FOR THE 2260 EFFECT.  10/77
CS B     BIEGERT 78 STUDIES TP FROM 1 TO 3 GEV/C. THEY OBSERVE STRONG     1/80*
CS B       VARIATION OF TP, WHICH MAY BE RELATED TO THE 2260 EFFECT SEEN  1/80*
CS B       IN OTHER STUDIES.                                              1/80*
CS R     BRYAN 78 OBTAINS I=0 PHASE SHIFTS FROM N P SCATTERING AT        12/79*
CS R       .325 GEV/C AT TRIUMF.                                         12/79*
CS O     HOSHIZAKI 78 AND 79 PREFORMS A PARTIAL WAVE ANALYSIS FOR P P     3/79*
CS O       INTERACTIONS IN THE C.M. MASS RANGE 2.1 TO 2.8 GEV.            3/79*
CS O     HOSHIZAKI 78 DISCRIBES A 3F3 STATE AT 2220 MEV.                  3/79*
CS O     HOSHIZAKI 79 DISCRIBES AHE 1D2 STATE AT 2170 MEV.                3/79*
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106 B=2, S=0 STATES - MASS (MEV)

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M  G    (2390.)                    GREIN     77 CNTR.               10/77
M  G    (2320.)                    GREIN     77 CNTR                10/77
M  E    (2260.)                    HIDAKA    77 CNTR                10/77
M  H    (2260.)                    HOSHIZAKI 77 PWA                 10/77
M  A    (2260.)                    AUER1     78 CNTR  3F3            3/79*
M  U    (2500.)                    AUER2     78 CNTR  1G4            3/79*
M  U    (2140.)                    AUER2     78 CNTR  1D2            3/79*
M  O    (2220.)                    HOSHIZAKI 78 PWA   3F3            3/79*
M  K    (2350.)                    KAMAE     78                     10/77
M  S    (2170.)                    HOSHIZAKI 79 PWA   1D2            3/79*
M  I    (2360.)                    IKEDA     79 CNTR                12/79*
M  M    (2187.)                    KAMO      79       1D2           12/79*
M  M    (2216.)                    KAMO      79       3F3           12/79*
M  G  GREIN 77 USES DATA OF DEBOER 75 AND AUER 77 FOR DISPERSION ANALYSIS 10/77
M  H  HOSHIZAKI 77 PRESENTS SOME RESULTS FROM A PARTIAL WAVE ANALYSIS OF  10/77
M  H    ARGONNE AND OTHER DATA. WIDTH OF THE 3F3 IS BETWEEN 90 AND 350.   10/77
M  A  AUER1 78 CONTINUES THE TRANSMISSION EXPERIMENT OF AUER 77.         . 3/79*
M  U  AUER2 78 AUGMENTS THE APPARATUS USED IN AUER2 78 TO MEASURE          1/80*
M  U    CLL FOR P P ELASTIC SCATTERING.                                    1/80*
M  O  HOSHIZAKI 78 GIVES A NEW ESTIMATE OF THE 3F3 MASS AND WIDTH,         3/79*
M  O    USING ADDITIONAL ARGONNE DATA.                                     3/79*
M  K  KAMAE 78 IS A GAMMA D --> P N EXP. BETWEEN .35 AND .75 GEV E GAMMA  10/77
M  K    THEY OBSERVE A SHARP PEAK IN POLARIZATION AT .5 GEV E(GAMMA)      10/77
M  I  IKEDA 79 IS A CONTINUATION OF KAMAE 78 AND MEASURES                 12/79*
M  I    GAMMA D --> P N ANGULAR DISTRIUTION BETWEEN .4 AND .65 GEV.       12/79*
M  I    THEY ASSUME THE 3F3 AT 2260, AND PREFORM A PWA.                   12/79*
M  M  KAMO 79 STUDIES P P --> PI+ D.  THEIR FITS HAVE SEVERAL OTHER       12/79*
M  M    RESONANCES, WITH UNSTABLE MASSES.                                 12/79*
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106 B=2, S=0 STATES - WIDTH(MEV)

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W  G     (100.0)                   GREIN     77 CNTR   2390 STATE   10/77
W  G     (290.0)                   GREIN     77 CNTR   2320 STATE   10/77
W  E     (200.0)                   HIDAKA    77 CNTR   2260 STATE   10/77
W  H     (150.)                    HOSHIZAKI 77 PWA    2260 STATE   10/77
W  O      50. TO  100.             HOSHIZAKI 78 PWA    2220 STATE    3/79*
W  I     (240.) TO (340.)          IKEDA     79 CNTR                 1/80*
W  S     100. TO  150.             HOSHIZAKI 79 PWA    2170 STATE    3/79*
W  M     (85.)                     KAMO      79        1D2          12/79*
W  M     (125.)                    KAMO      79        3F3          12/79*
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REFERENCES FOR B=2, S=0 STATES


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DEBOER    75 PRL 34 558          +R.FERNOW,A.KRISCH,+          (MICH+ANL+STLO)

AUER      77 PL 67B 113          +E.COLTON,D.HILL,K.NIELD,+        (ANL+NWES)
   ALSO   77  ANL-HEP-CP-7707    A.YOKOSOWA                            (ANL)
GREIN     77 NP B133 173         W.GREIN,P.KROLL                  (KARL+WUPP)
HIDAKA    77 PL 70B 479          +BERETVAS,H.NIELD,H.SPINKA,+          (ANL) JP
   ALSO   77 PL 70B 475          I.P.AUER,A.BERETVAS,E.COLTON,D.HILL,+ (ANL)
HOSHIZAK  77 PTP 58 716          N.HOSHIZAKI                         (KYOTO) JP
   ALSO   77 PTP 57 335          N.HOSHIZAKI,T.KADOTA                (KYOTO)
   ALSO   77 PTP 57 1099         N.HOSHIZAKI                         (KYOTO)

AUER1     78 PRL 41 354          +COLTON,HALPERN,HILL,SPINKA+          (ANL)
AUER2     78 PRL 41 1436         +BERETVAS,COLTON,HALPERN,HILL,NIELD+  (ANL)
BIEGERT   78 PL 73B 235          +BUCHANAN,CLEMENT,DRAGOSET+(RICE+MICH+HOUS)
BRYAN     78 PL 74B 321          R.BRYAN,R.CLARK+B.VERWEST            (TAMU)
   ALSO   78 PR C18 371          R.BRYAN,R.B.CLARK+B.VERWEST          (TAMU)
HOSHIZAK  78 PTP 60 1796         N.HOSHIZAKI                         (KYOTO)
KAMAE     78 NP B139 391         +I.ARAI,T.FUJII,H.IKEDA,+        (TOKY+KEK)
   ALSO   77 PRL 38 468          +I.ARAI,T.FUJII,H.IKEDA,+        (TOKY+KEK)
   ALSO   77 PRL 38 471          T.KAMAE AND T.FUJITA                 (TOKY)

HOSHIZAK  79 PTP 61 129          N.HOSHIZAKI                         (KYOTO)
IKEDA     79 PRL 42 1321         IKEDA,ARAI,FUJII,IWASAKI,KAJIURA+(TOKY,KEK)
KAMO      79 NCL 26 45           H.KAMO+W.WATARI                (R.I.A.E-OSU)
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PAPERS NOT REFERRED TO IN DATA CARDS

```
KANE      76 PRD 13 2944         G.L.KANE,G.H.THOMAS              (MICH+ANL)
BRAYSHAW  76 PRL 37 1329         D.D.BRAYSHAW                         (SLAC)
KLOET     77  LA-UR-77-2321      +R.R.SILBAN,R.AARON,+ (LASL+RUTG+NEAS+PENN)
MINAMI1   77  OCU-37             S.MINAMI                            (OSAKA)
MINAMI2   77 PL 74B 120          S.MINAMI                            (OSAKA)

KROLL     78 MORIOND 78, P331    P.KROLL                         (WUPPERTAL)
MINAMI    78 PR D18 3273         SHIGEO MINAMI                       (OSAKA)
UEDA      78 PTP 59 2            T.UEDA                              (OSAKA)
   ALSO   78 PL 74B 123          T.UEDA                              (OSAKA)
   ALSO   78 PL 79B 487          T.UEDA                              (OSAKA)

BUGG      79 J.PHYS G5 1349      D.V.BUGG                             (LOQM)
HIDAKA    79  ANL-HEP-PR-79-25   K.HIDAKA+A.YOKOSAWA                   (ANL)
MACGREGO  79 PRL 42 1724         MALCOLM MACGREGOR                     (LLL)
   ALSO   79 PRD 20 1616         MALCOLM MACGREGOR                     (LLL)
OHBA      79 PR D20 1115         ICHIRO OHBA                        (WASEDA)
WANTANBE  79 PR D19 1022         Y. WANTANBE                           (ANL)
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S=−1 →

107 BARYON NUMBER 2, STRANGENESS -1 STATES

THE POSITIVE EVIDENCE FOR A LAMBDA P RESONANCE COMES FROM EXPERIMENTS USING NUCLEAR TARGETS, USUALLY DEUTERIUM. THIS EVIDENCE IS COMPLICATED BY NUCLEAR EFFECTS, BUT EVEN MORE SERIOUS AMBIGUITIES ARISE FROM THE FACT THAT THE MOST LIKELY LAMBDA P RESONANCE, AT 2130 MEV, LIES PRECISELY AT SIGMA NUCLEON THRESHOLD.

BRAUN 77 EXAMINE THE T DEPENDENCE OF THE 2130 MEV ENHANCEMENT AND FIND TWO COMPONENTS. THE PERIPHERALLY PRODUCED PART OF THE 2130 MEV PEAK IS NARROW AND HAS A STEEP T DEPENDENCE, WHILE THE LARGE T EVENTS FORM A BROAD ENHANCEMENT AT SIGMA NUCLEON THRESHOLD, WHICH IS INTERPRETED AS NON-RESONANT. BRAUN 77 FAVOR THE DEUTERON-LIKE 3S1 ASSIGNMENT FOR THE NARROW PEAK ON THE BASIS OF ITS PERIPHERAL PRODUCTION, BUT THEY CANNOT EXCLUDE THE POSSIBILITY THAT IT IS A NON-RESONANT CUSP EFFECT.

DOSCH 78 ANALYZES THE 2130 EFFECT BY CALCULATING DIRECTLY THE ABSORPTION PART DUE TO THE SIGMA-NUCLEON IN THE LAMBDA-P CHANNEL AND DETERMINING THE DISPERSIVE PART BY A DISPERSION RELATION. DOSCH 80 EXTENDS THIS ANALYSIS TO SHOW THAT THERE IS A POLE IN THE 3S1 AMPLITUDE CORRESPONDS TO AS A BOUND STATE IN THE SIGMA-N CHANNEL AND A RESONANCE IN THE LAMBDA-P CHANNEL.

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     EXPERIMENTS USING FREE HYPERON BEAMS MAY LACK THE STATISTICAL
  SENSITIVITY TO OBSERVE THE 2130 MEV EFFECT SEEN IN THE NUCLEAR
  TARGET DATA.
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107 LAMBDA P(2130) PEAK - CROSS SECTION (MICROBARNS)

```
CS        NOT SEEN                 ALEXANDER 68 HBC    LAM P ELASTIC    10/77
CS        NOT SEEN                 BUNNEL    70 HEBC   K- STOP IN HE    10/77
CS        NOT SEEN                 KADYK     71 HBC    LAMBDA P SCATTER 10/77
CS        NOT SEEN                 HAUPTMAN  74 HBC    LAMBDA P ELASTIC 10/77
CS         (25.)      (5.)         BRAUN     77 DBC    K-D .68-.84 GEV/  2/78
CS  Z      (22.0)     (7.0)        SHAHBAZ3  78 HLBC   N C AT 7 GEV/C   12/79*
CS R      NOT SEEN                 ROOSEN    79 HEBC   K- STOPS IN HE   12/79*
CS O      SEEN                     DOSCH     80 DBC                      1/80*
CS  Z   SHAHBAZ3 78 CLAIMS PEAK AS EITHER RESONANCE OR SIGMA-NUCLEON    12/79*
CS  Z     SCATTERING LENTH EFFECT.                                      12/79*
CS R    ROOSEN 79 STUDIES K- HE --> LAMBDA PI- P D AT REST.             12/79*
CS R      THEY FIT THE PEAK WITH A MODEL INVOLVING ONLY LAMBDA-SIGMA    12/79*
CS R      CONVERSICN AND RESCATTERING PROCESSES. MOST OF THE PEAK       12/79*
CS R      IS DUE TO LAMBDA-SIGMA CONVERSION OFF A SINGLE NUCLEON.       12/79*
CS O    DOSCH 80 CLAIMS 2130 PEAK CONTAINS A STATE WHICH IS LAMBDA-P     1/80*
CS O      RESONANCE AND SIGMA-NUCLEON BOUND STATE.                       1/80*
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107 LAMBDA P(2130) PEAK - MASS (MEV)

```
M        (2126.)                   CLINE     68 DBC    K- AT 400 MEV/C  10/77
M        (2130.)                   ALEXANDER 69 DBC    K- FROM.9TO1.1   10/77
M  J     (2110.)                   JAIN      69 EMUL   K- AT REST       10/77
M  F      2128.        .2          TAN       69 DBC                     10/77
M  E     (2129.0)                  EASTWOOD  71 DBC                     10/77
M  I      2127.0      1.0          SIMS      71 DBC                     10/77
M  S      2125.2      2.5          SHAHBAZIA 73 HLBC                    10/77
M        (2115.)                   SODHI     75 DBC    K- D AT 1.4+1.6   3/79*
M         2129.0      0.4          BRAUN     77 DBC    K-D .68-.84 GEV/ 10/77
M  D     (2129.)                   DOSCH     78                         12/79*
M  G     (2130.)                   GOYAL     78        K-D AT 1.4+1.6    3/79*
M  P     (2128.4)                  NISHIMURA 78                          3/79*
M    Z   (2128.4)                  SHAHBAZ3  78                          1/80*
M  N     (2128.9)                  NAGELS    79                         12/79*
M  O     (2129.3)                  DOSCH     80                          1/80*
M  J    GOYAL 71 RAISES DOUBTS ABOUT THE EXPERIMENTAL PROCEDURE USED IN 12/79*
M  J      JAIN 69.                                                      12/79*
M  F    TAN 69 IS STOPPING K- IN DEUTERIUM.  THEY OBSERVE A SECONDARY   10/77
M  F      SHOLDER AT 2139 MEV.                                          10/77
M  E    EASTWOOD 71 IS K- D  AT 1.45 AND 1.65 GEV/C                     10/77
M  I    SIMS 71 IS K- D FROM .67 TO .925 GEV    3 + 4 BODY PEAK.        10/77
M  S    SHAHBAZIAN 73 IS N C AT 7.5 AND PI- C AT 4.                     10/77
M  S      2125.2 PEAK NOT CLAIMED AS A RESONANCE -- RATHER (SIGMA, P)    3/79*
M  S      SCATTERING LENGTH EFFECT.                                      3/79*
M  G    GOYAL 78 OBSERVE PEAK, DO NOT CLAIM RESONANCE.                   3/79*
M  P    NISHIMURA 78 IS A PHASE SHIFT ANALYSIS OF DATA OF BRAUN77 AND TAN69  3/79*
M  P      CONCLUDES THE 3S1 PHASE CROSSES 90 BELOW (SIG,P) THRESHOLD.    3/79*
M  D    DOSCH 78 ANALYZES DATA OF EASTWOOD 71 AND BRAUN 77.  THEY CONCLUDE 12/79*
M  D      THAT THE 2129 PEAK IS DUE TO A COMBINED EFFECT OF A CUSP DUE TO 12/79*
M  D      THE DEUTERON AND A SHARP MAXIMUM IN THE SIG N --> LAM N AMPLITUDE 12/79*
M  N    NAGELS 79 MASS AND WIDTH ARE FROM POLE POSITION GIVEN BY A      12/79*
M  N      POTENTIAL MODEL ANALYSIS.                                     12/79*
M  O    DOSCH 80 MASS AND WIDTH ARE FROM POLE POSITION.                  1/80*
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107 LAMBDA P(2130) PEAK - WIDTH(MEV)

```
W          (10.)                   CLINE     68 DBC                     10/77
W  J       (20.)                   JAIN      69 EMUL                    10/77
W  F        7.         .6          TAN       69 DBC                     10/77
W  E       (20.0)                  EASTWOOD  71 DBC                     10/77
W  I        8.0       1.0          SIMS      71 DBC                     10/77
W  S       20.6       5.2          SHAHBAZIA 73 HLBC                    10/77
W         (150.)                   SODHI     75 DBC    K- D AT 1.4+1.6   3/79*
W           5.9       1.6          BRAUN     77 DBC    K-D .68-.84 GEV/ 10/77
W    Z      2.3       0.6          SHAHBAZ3  78 HLBC   N C AT 7 GEV/C    3/79*
W  N       (4.78)                  NAGELS    79                         12/79*
W  O       (10.3)                  DOSCH     80                          1/80*
```

107 OTHER LAMBDA P PEAKS - CROSS SECTION (MICROBARNS)

```
CS   Z      85.3      20.0         SHAHBAZ3  78 HLBC    2256.5 PEAK      3/79*
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107 OTHER LAMBDA P PEAKS - MASS (MEV)

```
M         2098.       6.           COHN      64 HEBC SIGMA- STOPS IN HE 12/79*
M    S   (2251.4)    (3.9)         SHAHBAZIA 73 HLBC                    10/77
M    H   (2256.5)    (1.)          SHAHBAZ1  78 HLBC                     3/79*
M    M  SHAHBAZ1 78 CLAIMS 2256 PEAK AS A RESONANCE.                     3/79*
```

107 OTHER LAMBDA P PEAKS - WIDTH(MEV)

```
W           20.       10.          COHN      64 HEBC SIGMA- STOPS IN HE 12/79*
W  S       (21.1)    (5.4)         SHAHBAZIA 73 HLBC    2251.4 PEAK     10/77
W  H       (10.)     (1.2)         SHAHBAZ1  78 HLBC    2256 PEAK        3/79*
```

REFERENCES FOR B=2, S=-1 STATES


```
COHN      64 PRL 13 668       H.O.COHN,K.BHATT,W.M.BUGG          (ORNL+TENN)
ALEXANDE  68 PR 173 1452      ALEXANDER,U.KASHORN,A.SHAPIRA,+    (REHO+HEID)
CLINE     68 PRL 20 1452      +R.LAUMANN+J.MAPP                       (WISC)
ALEXANDE  69 PRL 22 483       ALEXANDER,HALL,JEW,KALMUS,KERNAN    (LBL+UCR)
JAIN      69 PR 187 1816      P.L.JAIN                                (BUFF)
TAN       69 PRL 23 395       TAI HO TAN                              (SLAC)
BUNNEL    70 PR D2 98         +DERRICK,FIELDS,HYMAN+KEYES         (NWES+ANL)

EASTWOOD  71 PR D3 2603       +FRY,HEATHCOTE,ISLAN,+(BIRM+EDIN+GLAS+LOIC)
KADYK     71 NP B27 13        +ALEXANDER,CHAN,GAPOSCHKIN+TRILLING    (LBL)
SIMS      71 PR D3 1162       +ONEALL,ALBRIGHT,BRUCKER+LANNUTTI      (FSU)

SHAHBAZI  73 NP B53 19        B.SHAHBAZIAN+A.TIMONINA                (JINR)
HAUPTMAN  74  LBL-3608        J.M.HAUPTMAN (THESIS)                   (LBL)
SODHI     75 NP B97 403       A.SODHI+D.GOYAL                       (DELHI)

BRAUN     77 NP B124 45       +H.GRIMM,V.HEPP,H.STROBELE,+     (HEID+MPIM)
DOSCH     78 PR D18 4071      H.DOSCH+V.HEPP                         (HEID)
GOYAL     78 PRD 18 948       D.GOYAL+A.SODHI                       (DELHI)
NISHIMUR  78  UT-309          A.NISHIMURA                            (TOKY)
SHAHBAZ1  78  JINR-E1-11774   B.SHAHBAZIAN                           (JINR)
SHAHBAZ3  78  JINR-E1-11877   B.SHAHBAZIAN,TEMNIKOV,TIMONINA,+       (JINR)
    ALSO  76  JINR-D1,2-10400 B.SHAHBAZIAN,TEMNIKOV,TIMONINA,+       (JINR)

NAGELS    79 PR D20 1633      M.NAGELS,T.RIJKEN+DE SWART             (NIJM)
ROOSEN    79 NC 49 217        +VANDERVELDE-WILQUET,WICKENS+     (LOUC+BRUX)

DOSCH     80 TO BE PUB IN ZP,C H.DOSCH+STAMATESCU                    (HEID)
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PAPERS NOT REFERRED TO IN DATA CARDS

```
DAHL      61 PRL 6 142        O.DAHL,N.HORWITZ,D.MILLER,J.MURRAY,+  (LBL)
PIROUE    64 PL 11 164        P.A.PIROUE                             (PRIN)
GOYAL     71 PR D3 1259       D.P.GOYAL                             (DELHI)
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S=−2 →

108 BARYON NUMBER 2, STRANGENESS -2 STATES

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     EXPERIMENTAL EVIDENCE FOR RESONANCES IN THE STRANGNESS = -2
  DIBARYON SYSTEMS IS NOT VERY STRONG, THOUGH RESONANCES ARE PREDICTED
  (JAFFE 77).
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108 B=2, S=-2 STATES - CROSS SECTION (MICROBARNS/NUCL.)

```
CS        (10.0)     (7.0)         BEILLIERE 72 HLBC   K- AT 2.2 GEV/C   2/78
CS W      NOT SEEN                 WILQUET   75 HLBC   K- AT 2.2 GEV/C  10/77
CS A      NOT SEEN                 GUY       77 HBC    K- PT AT 12 GEV  10/77
CS S       24.2       7.0          SHAHBAZ2  78 HLBC   N C AT 7 GEV/C    3/79*
CS W    WILQUET 75 SUPERSEDES BEILLIERE 72 WITH TWICE AS MUCH DATA.  THEY 10/77
CS W      LOOK AT XI INTERACTIONS FROM .8 TO 2.2 GEV/C.                 10/77
CS A    GUY 77 IS 12 GEV K- ON PT PLATES FORMS LAMBDA BEAM.             10/77
CS A      SUGGESTS BROAD, LOW MASS PEAK IS DUE TO RESCATTERING          10/77
CS S    SHAHBAZ2 78 GIVE CS IN MU-BARN/NUCLEUS FOR LAMBDA-LAMBDA RESONANCE.  3/79*
```

108 B=2, S=-2 STATES - MASS (MEV)

```
M        (2370.0)                  BEILLIERE 72 HLBC   K- AT 2.1        10/77
M        (2365.3)    (9.6)         SHAHBAZIA 73 HLBC   2 ST.DEV. PEAK   10/77
M        (2480.)                   GOYAL     79 DBC    1.4^1.65 K- D     1/80*
```

108 B=2, S=-2 STATES - WIDTH(MEV)

```
W          (47.2)    (15.1)        SHAHBAZIA 73 HLBC    2365 MEV PEAK   10/77
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REFERENCES FOR B=2, S=-2 STATES


```
BEILLIER  72 PL 39B 671       BEILLIERE,MAYEUR,+     (BRUX+CERN+TUFT+LOUC)
SHAHBAZI  73 NP B53 19        B.SHAHBAZIAN,A.TIMONINA                (JINR)
WILQUET   75 PL 57B 97        +KNIGHT,GUY,+     (BRUX+TUFT+LOUC+CERN+RHEL)
GUY       77  RL-77-054-A     J.G.GUY+J.KADYK                    (RHEL+LBL)
SHAHBAZ2  78  JINR-E1-11839   B.SHAHBAZIAN,P.TEMNIKOV+A.TIMONINA     (JINR)
GOYAL     79  TO APPEAR IN PRD D.GOYAL,J.MISRA,A.SODHI              (DELHI)
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PAPERS NOT REFERRED TO IN DATA CARDS

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JAFFE     77 PRL 38 195       R.L.JAFFE                          (SLAC+MIT)
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115 BARYON NUMBER >=2, STRANGENESS -2 STATES

115 B>=2, S=-2 STATES - CROSS SECTION (MICROBARNS)

```
CS S        16.1      5.2          SHAHBAZ2  78 HLBC    N C AT 7 GEV/C   3/79*
CS S    SHAHBAZ2 78 EFFECT IS FOR B=3.
CS C     LESS THAN .13             CARROLL   78 SPEC    P P -> 2K+ ANY   3/79*
CS C    CARROLL 78 SET UPPER LIMITS FROM .03 TO .13 MU-BARN FOR DILAMBDA  3/79*
CS C      STATES.                                                        3/79*
```

115 B>=2, S=-2 STATES - MASS (MEV)

```
M  S     (3568.3)                  SHAHBAZ2  78 HLBC                     3/79*
```

115 B>=2, S=-2 STATES - WIDTH(MEV)

```
W  S       <60.                    SHAHBAZ2  78 HLBC                     3/79*
```

REFERENCES FOR B>=2, S=-2 STATES


```
CARROLL   78 PRL 41 777       +CHIANG,JOHNSON,KYCIA,KI,+         (BNL+PRIN)
SHAHBAZ2  78  JINR-E1-11839   B.SHAHBAZIAN,P.TEMNIKOV+A.TIMONINA     (JINR)
```

Appendix I

TEST OF $\Delta I=1/2$ RULE FOR K DECAYS

The quantities of interest for making tests of theoretical predictions regarding the $\Delta I=1/2$ rule for K decay are usually partial decay rates for single channels or special sums of channels. It is not possible to compute the errors on sums, differences, and ratios of partial decay rates from the information given in the Table of Stable Particles because of the presence of off-diagonal terms in the error matrix. For this reason we give some of these quantities in Table I. Throughout this Appendix, italics are used to indicate that a quantity has changed by more than one (old) standard deviation since our previous edition, and S gives the scale factor included in the quoted error because of inconsistencies in the data (see footnote at end of Stable Particle Table for definition of S).

Table I. (000) and (+−0) refer to the sign of the pions into which the K_L decays.

$\Gamma_{K^+_{\ell 3}} = \Gamma_{K^+_{e3}} + \Gamma_{K^+_{\mu 3}}$	$= (6.484\pm0.089)10^6\ \text{sec}^{-1}$	
$\Gamma_{K^+_{\mu 3}} / \Gamma_{K^+_{e3}}$	$= 0.663\pm0.018$	S=1.7*
$\Gamma_{K^+_{\tau}} / \Gamma_{K^+_{\tau'}}$	$= 3.226\pm0.082$	
$\Gamma_{K^0_{\ell 3}} = \Gamma_{K^0_{e3}} + \Gamma_{K^0_{\mu 3}}$	$= (12.70\pm0.15)10^6\ \text{sec}^{-1}$	S=1.1*
$\Gamma_{K^0_{\mu 3}} / \Gamma_{K^0_{e3}}$	$= 0.695\pm0.017$	
$\Gamma_{K^0(000)} / \Gamma_{K^0(+-0)}$	$= 1.733\pm0.076$	S=1.3*

1. Leptonic decay rates

The $\Gamma_{K_{\ell 3}}$ rates are useful in testing the leptonic $\Delta I=1/2$ rule in the way suggested by Trilling.[1] The predictions are

$$\Gamma_{K^0_{\ell 3}} / 2\Gamma_{K^+_{\ell 3}} = 1.012, \text{ a phase-space factor,}^{2}$$

and

$$\Gamma_{K^0_{\mu 3}} / \Gamma_{K^0_{e3}} = \Gamma_{K^+_{\mu 3}} / \Gamma_{K^+_{e3}} .$$

From Table 1,

$$\Gamma_{K^0_{\ell 3}} / 2\Gamma_{K^+_{\ell 3}} = 0.979\pm0.018$$

and

$$\frac{\Gamma_{K^0_{\mu 3}}}{\Gamma_{K^0_{e3}}} \left[\frac{\Gamma_{K^+_{\mu 3}}}{\Gamma_{K^+_{e3}}} \right]^{-1} = 1.048\pm0.038 .$$

These results seem to show a less than 2σ disagreement with the predictions, but the errors should be regarded with caution in view of the internal disagreements in the data. (Note the ideograms in the Data Listings for the charged K meson.)

2. Three-pion decays

We follow here the tests done by Mast et al.,[3] based on the general analysis of K decays suggested by Zemach.[4] Both decay rates (Γ) and slopes (g, the energy dependence of the Dalitz plot distributions) are used. The $\Delta I=1/2$ rule predicts that the following test quantities are all equal to zero:

$$\text{Test 1} = \frac{2}{3} \frac{\Gamma_{K^0(000)}}{\phi_1} \left[\frac{\Gamma_{K^0(+-0)}}{\phi_2} \right]^{-1} -1 ,$$

$$\text{Test 2} = \frac{1}{4} \frac{\Gamma_{K^+_\tau}}{\phi_3} \left[\frac{\Gamma_{K^+_{\tau'}}}{\phi_4} \right]^{-1} -1 ,$$

$$\text{Test 3} = \frac{1}{2} \frac{\Gamma_{K^+_\tau}}{\phi_3} \left[\frac{\Gamma_{K^0(+-0)}}{\phi_2} \right]^{-1} -1 ,$$

$$\text{Test 4} = \frac{1}{2} g_{K^+_{\tau'}} + g_{K^+_\tau} ,$$

$$\text{Test 5} = g_{K^0(+-0)} + g_{K^+_\tau} - \frac{1}{2} g_{K^+_{\tau'}} .$$

The ϕ_i are phase-space factors which have been calculated as described in Mast et al.[3] by use of a relativistic formulation and the masses and slopes from this edition. The factors labeled UDP are the relative areas of the Dalitz plots, assuming a uniform distribution. The NUDP include the observed slopes (see below). The CNUDP have been calculated by including the final-state Coulomb interaction.
The values are:

	Method		
	UDP	NUDP	CNUDP
$\phi_1(000) =$	1.490	1.490	1.444
$\phi_2(+-0) =$	1.221	1.303	1.287
$\phi_3(++-) =$	1.000	1.000	1.000
$\phi_4(+00) =$	1.247	1.173	1.137

For convenience, we repeat the slope parameters tabulated in the Stable Particle Table. They are as follows:

$g_{K^+_\tau}$	$= -0.215\pm0.004$	S=1.4*
$g_{K^-_\tau}$	$= -0.217\pm0.007$	S=2.5*
$\bar{g}_{K^\pm_\tau}$	$= -0.215\pm0.003$	
$g_{K^+_{\tau'}}$	$=$ *0.607±0.030*	*S=1.3**
$g_{K^0(+-0)}$	$= 0.670\pm0.014$	S=1.6*

A difference in the τ^+ and τ^- slopes would be an indication of CP violation in this decay. Since no difference is observed at this time, we average he two and use this value in Test 4 and Test 5.

We use the CNUDP factors and the rates and slopes reported in this edition to compute the five test quantities which the $\Delta I=1/2$ rule predicts to be zero. The results are:

Test 1 = 0.030±0.045
Test 2 = −0.083±0.023
Test 3 = 0.216±0.020
Test 4 = *0.088±0.016*
Test 5 = *0.152±0.021*

The three-pion final state can be in isospin states I = 1,2,3. Tests 1 and 2 test the existence of isospin I = 3 in the final state. Since the rate tests (Tests 1, 2, and 3) could differ from zero by as much as 0.1 owing to the mass differences and the occurrence of big slopes[5], no evidence for I=3 is found. Test 4 is related to the I=2 amplitude in the final state and indicates the presence of I=2. Tests 3 and 5 give information on the $\Delta I=3/2$ part of the I=1 amplitude relative to the $\Delta I=1/2$ part. Both tests indicate the presence of $\Delta I=3/2$.

References

1. G. Trilling, K-Meson Decays, UCRL-16473, (updated from Argonne Conference Proceedings, 1965, p. 115).
2. N. Brene (CERN), private communication. In our Jan. 1968 edition we had erroneously used 1.04.
3. T. S. Mast, L. K. Gershwin, M. Alston-Garnjost, R. O. Bangerter, A. Barbaro-Galtieri, J. J. Murray, F. T. Solmitz, and R. D. Tripp, Phys. Rev. 183, 1200 (1969).
4. C. Zemach, Phys. Rev. 133, B1201 (1964).
5. C. Bouchiat and M. Veltman, Topical Conference on Weak Interactions, CERN 69-7 (1969), p. 225.

Appendix II

TEST OF $\Delta I=1/2$ RULE FOR HYPERON DECAYS

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1. Nonleptonic decay Amplitudes

In this edition we again use the new convention for the amplitudes A and B adopted in 1973. Some theorists have suggested that dimensionless amplitudes are more useful to them than the ones appearing in the literature. Berge[1] used a convention with A and B in units of $\sec^{-1/2}$. Samios[2] used a convention which gave A and B in units of $(\text{MeV-sec})^{-1/2}$. Following is the convention suggested by Jackson[3], which gives dimensionless A and B.

The effective Lagrangian density for nonleptonic hyperon decays ($B_1 \to B_2 + \pi$) can be written

$$\mathcal{L}_{eff} = G\mu_c^2[\overline{\psi}_2(A+B\gamma_5)\psi_1]\phi_\pi,$$

where $G=10^{-5}m_p^{-2}$ is a coupling constant characteristic of first-order weak decays, μ_c is the charged pion mass, and A and B are dimensionless complex numbers giving the relative amplitudes of the parity-violating and parity-conserving decays, respectively. The matrix γ_5 is to be taken in the Pauli form, $\gamma_5=\begin{pmatrix} 0 & -I \\ -I & 0\end{pmatrix}$. The invariant amplitude for the decay is

$$\mathcal{M} = G\mu_c^2[\overline{u}(p)(A+B\gamma_5)u(P)],$$

where P is the 4-momentum of the decaying hyperon of mass M, and p is the 4-momentum of the baryon decay product of mass m. With the normalization convention, $\overline{u}_i u_i = 2m_i$, the Pauli form of the matrix element in the rest frame of the decaying hyperon is

$$\mathcal{M} = G\mu_c^2\langle\chi_2|\sqrt{2M(E+m)}A + \sqrt{2M(E-m)}\,B\vec{\sigma}\cdot\hat{q}|\chi_1\rangle,$$

where E is the total energy of the final baryon and $\hat{q}$ is a unit vector in the direction of motion of the final baryon. Comparison with Sec. VI D of the text shows that the amplitudes s and p defined there are proportional to A and B:

$$\frac{p}{s} = \left(\frac{E-m}{E+m}\right)^{1/2}\frac{B}{A} = \left[\frac{(M-m)^2-\mu^2}{(M+m)^2-\mu^2}\right]^{1/2}\frac{B}{A}.$$

Here μ is the mass of the pion entering the decay. The parameters α, β, and γ can therefore be expressed in terms of A and B, rather than s and p, if desired.

The decay rate for $B_1 \to B_2 + \pi$ is

$$\Gamma = \frac{G^2\mu_c^4}{8\pi}\,q\left\{\left[\frac{(M+m)^2-\mu^2}{M^2}\right]|A|^2 + \left[\frac{(M-m)^2-\mu^2}{M^2}\right]|B|^2\right\},$$

where q is the c.m. momentum of the decay products. For reference, the dimensionless constant in this expression has the value $(G^2\mu_c^4/8\pi) = 1.9488\times10^{-15}$.

Table I summarizes the amplitudes A and B for the nonleptonic decays of the Λ, Σ, and Ξ hyperons. These amplitudes have been calculated by using the experimental data for mean lives, branching ratios, and the decay asymmetry α given in the Stable Particle Table of this Review. Time-reversal invariance is assumed and final-state interactions are neglected, so A and B are taken to be relatively real. The subscript on the hyperon refers to the sign of the decaying pion. The statistical correlation coefficient

$$C_{AB} = \frac{\langle \Delta A \Delta B\rangle}{\sqrt{\langle \Delta A^2\rangle\langle \Delta B^2\rangle}}$$

is also given. The absolute signs of A and B have been assigned, using the following convention. Taking $A(\Lambda^0_-)$ as positive, the other S-wave decay amplitudes are chosen to give an approximate fit to the triangular relationships

$$\sqrt{2}A(\Sigma^+_0) + A(\Sigma^+_+) = A(\Sigma^-_-) \text{ and } \sqrt{3}A(\Sigma^+_0) + A(\Lambda^0_-) = 2A(\Xi^-_-).$$

The signs of the B amplitudes relative to those of the corresponding A amplitudes are determined by the sign of the appropriate α decay parameter.

Table I

$M \to m + \mu$	A	B	C_{AB}
$\Lambda^0_- \to p + \pi^-$	1.47±0.01	9.98±0.24	−0.289
$\Lambda^0_0 \to n + \pi^0$	−1.07±0.01	−7.14±0.56	−0.741
$\Sigma^+_+ \to n + \pi^+$	0.06±0.01	19.07±0.07	−0.038
$\Sigma^+_0 \to p + \pi^0$	1.48±0.05	−12.04±0.58	0.982
$\Sigma^-_- \to n + \pi^-$	1.93±0.01	−0.65±0.07	0.003
$\Xi^0_0 \to \Lambda + \pi^0$	1.54±0.03	−6.43±0.66	0.188
$\Xi^-_- \to \Lambda + \pi^-$	2.04±0.01	−6.93±0.31	0.268

2. Tests of the $\Delta I=1/2$ Rule

(a) Λ Decay

For Λ decay the $\Delta I=1/2$ rule predicts that $\Gamma_0/\Gamma_- = 0.50$ and $\alpha_0 = \alpha_-$. In order to determine the magnitude of possible $\Delta I=3/2$ amplitudes present we write the linear expressions[4] for the $\Delta I=3/2$ A- and B-wave amplitudes in terms of $\Delta\alpha$, where $\Delta\alpha$ is the measured value of α_0/α_- minus the predicted value, and in terms of $\Delta\Gamma$ similarly defined. Evaluating these we find

$$\Delta\alpha = -1.54\,(A_3/A_1) + 1.61\,(B_3/B_1),$$
$$\Delta\Gamma = 1.84\,(A_3/A_1) + 0.25\,(B_3/B_1).$$

Here the $\Delta I=3/2$ amplitudes are expressed relative to the $\Delta I=1/2$ amplitudes. The numerical values of the coefficients depend on the ratio B/A. The uncertainties in the coefficients are small compared to the uncertainties in $\Delta\alpha$ and $\Delta\Gamma$. Final-state πN interactions have been included in these relations but have a very small effect. From the Stable Particle Table,

$$\Delta\alpha = 0.006\pm0.066, \quad \Delta\Gamma = 0.058\pm0.012,$$

and hence

$$(A_3/A_1) = 0.027\pm0.008$$

and

$$(B_3/B_1) = 0.030\pm0.037.$$

The possible 3% $\Delta I=3/2$ A-wave amplitude is due to the disagreement of decay rates with prediction. At this level the results are sensitive to electromagnetic corrections. However, in Λ decay the phase space correction and the other radiative corrections appear to be about equal in magnitude and have opposite signs,[5,6] and hence cancel each other in the correction to the decay rates.

(b) Ξ Decay

The analysis for Ξ decay is very similar to that for Λ decay. If the $\Delta I=1/2$ rule is valid, $\Gamma_0(\Xi^0)/\Gamma_-(\Xi^-) = 0.50$ and $\alpha_0 = \alpha_-$. For this case the expressions linear in $\Delta I=3/2$ A- and B-wave amplitudes are[4]

$$\Delta\alpha = 1.37\,(A_3/A_1) - 1.37\,(B_3/B_1),$$
$$\Delta\Gamma = -1.44\,(A_3/A_1) - 0.06\,(B_3/B_1).$$

From the Stable Particle Table,

$$\Delta\alpha = 0.18\pm0.12, \quad \Delta\Gamma = 0.066\pm0.020,$$

and we find

$$(A_3/A_1) = -0.038\pm0.014$$

and

$$(B_3/B_1) = -0.17\pm0.09.$$

(c) Σ Decay

The traditional test of the $\Delta I=1/2$ rule in Σ decay is that the amplitudes satisfy the relationship

$$\sqrt{2}\,\Sigma^+_0 + \Sigma^+_+ - \Sigma^-_- = 0 \ .$$

Graphically this is equivalent to closing the Σ triangle when the amplitudes are plotted on A, B axes. Including $\Delta I\geq3/2$ amplitudes in Σ decay analysis, the "Σ triangle" relationship becomes

$$\sqrt{2}\,A_0 + A_+ - A_- = -3\sqrt{2/5}\,A_3 + \frac{2}{\sqrt{15}}\,A_5 \ ,$$

where A_3 and A_5 are $\Delta I=3/2$ and $\Delta I=5/2$ amplitudes, respectively. There is a similar equation for the B amplitudes. From Table I,

$$\sqrt{2}A_0 + A_+ - A_- = 0.22\pm0.09$$

and

$$\sqrt{2}B_0 + B_+ - B_- = 2.7 \pm1.0 \ .$$

If we neglect the $\Delta I=5/2$ amplitudes and assume all amplitudes to be real we can solve for possible $\Delta I=3/2$ amplitudes. The result is

$$\frac{A_3}{A_-} = -0.061\pm0.024$$

and

$$\frac{B_3}{B_+} = -0.074\pm0.027 \ .$$

Thus for hyperon decay, present experimental data limit $\Delta I=3/2$ amplitudes to less than about 5%.

3. The Lee–Sugawara Relation

From Table I the Lee–Sugawara relation,[7,8] $\sqrt{3}\Sigma_0^+ + \Lambda_-^0 - 2\Xi_-^-= 0$, is satisfied to -0.07 ± 0.11 for the A amplitudes, and to 3.0 ± 1.9 for the B amplitudes.

References

1. J. P. Berge, in Proceedings of the 13th International Conference on High-Energy Physics, Berkeley, (1966) (University of California Press, Berkeley, 1967), p. 46.
2. N. P. Samios, International Conference on Weak Interactions, Argonne, (1965), p. 189.
3. J. D. Jackson, private communication (1973).
4. See O. E. Overseth and S. Pakvasa, Phys. Rev. 184, 1663 (1969). The expression for Γ_0/Γ_- for Λ decay should read

$$\frac{\Gamma_0}{\Gamma_-} \approx \frac{1}{2}\left\{1+3\sqrt{2}\times\left[\frac{S_{11}S_{33}\cos(\delta_1-\delta_3)+P_{11}P_{33}\cos(\delta_{11}-\delta_{31})}{S_{11}^2+P_{11}^2}\right]\right\} .$$

5. See A. A. Belavin and I. M. Narodetsky, Yadern. Fiz. 8, 978 (1968) [Soviet J. Nucl. Phys. 8, 568 (1969)].
6. G. W. Intemann, private communication (1973).
7. See B. W. Lee, Phys. Rev. Lett. 12, 83 (1964).
8. See H. Sugawara, Prog. Theor. Phys. 31, 213 (1964).

Appendix III

A. SU(3) CLASSIFICATION OF BARYON RESONANCES

A. Barbaro–Galtieri

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It is established that a symmetry higher than SU(3) is necessary to classify the known baryon resonances. However, many higher-symmetry schemes have been proposed, and even for SU(6) various versions exist (for a review see Dalitz[1]). Since it is not clear which one of these schemes best fits the data, we do not review them here, but we report once again fits of baryon states into SU(3) multiplets.

For the reader's convenience, we collect here the relevant formulae.

Exact SU(3) symmetry predicts that all the members of a multiplet should have the same mass and the same couplings for decays into other multiplets. It has been found, however, that the members of the octet of stable baryons lie within 20% of their mean mass; therefore a symmetry-breaking interaction has been introduced by Gell-Mann and Okubo independently.[2] In addition, for the isospin-0 vector mesons (ω and ϕ), an additional symmetry-breaking interaction has been introduced by Sakurai[3] to take care of octet-singlet mixing. The relevant formulae for masses and decay rates are given below.

Mass Formulae

Broken SU(3) gives:

Decuplet	$\Delta - \Sigma = \Sigma - \Xi = \Xi - \Omega$	GMO	(1)
Octet	$2(N + \Xi) = 3\Lambda + \Sigma$	GMO	(2)
Octet–Singlet mixing	$\sin^2\theta = \dfrac{\Lambda - M_8}{\Lambda - \Lambda'}$	Mixing angle[4]	(3)
	$M_8 = \dfrac{2(N + \Xi) - \Sigma}{3}$	GMO	(4)

Here GMO stands for the Gell–Mann–Okubo formula; the particle symbol indicates its mass. The formulae would be the same if squared masses were used. For the nonet case, Λ is the "mostly-octet" particle, Λ' is the "mostly-singlet" particle.

Decay Rates

In terms of a relativistically invariant matrix element T, the decay rate for two-body decay of a resonance of mass M_R is

$$\Gamma \propto \frac{|T|^2R_2}{M_R} \ , \qquad (5)$$

where $R_2=k/M_R$ is the two-body phase space factor. Since the numerator is an invariant, and since Γ must transform as $1/E$, we introduce the denominator M_R.[5]

For meson decays (see below) the rates are calculated according to Eq. (5); for baryon resonance decays into $1/2^+$ baryons and 0^- mesons, one next takes into account the fact that spin sums in $|T|^2$ introduce another factore M_R, cancelling the $1/M_R$. We are then left with

$$\Gamma = \frac{|T|^2 k}{M_R} M_N \text{ , for baryons} \qquad (5')$$

$$= \frac{|T|^2 k}{M_R^2} M_N^2 \text{ , for mesons.} \qquad (5'')$$

The powers of the nucleon mass M_N or M_N^2 have been introduced so that we can treat $|T|$ as dimensionless.

$|T|^2$ contains centrifugal barrier factors, which we call B_ℓ. We then have

$$\left.\begin{array}{l}\text{Decuplet}\\ \text{Singlet}\end{array}\right\} \quad \Gamma = (cg)^2 B_\ell(k) \frac{M_N}{M_R} k \qquad (6)$$

$$\text{Octet} \quad \Gamma = (c_D g_D + c_F g_F)^2 B_\ell(k) \frac{M_N}{M_R} k \qquad (7)$$

$$\left.\begin{array}{l}\text{Octet–}\\ \text{Singlet}\\ \text{mixing}\end{array}\right\} \quad \begin{array}{l}\Lambda = G_8 \cos\theta + G_1 \sin\theta\\ \Lambda' = -G_8 \sin\theta + G_1 \cos\theta\end{array} \qquad 8)$$

$$\text{with} \quad \begin{array}{l} G_8 = c_D g_D + c_F g_F \\ G_1 = c_1 g_1 \ . \end{array} \qquad (9)$$

Here c_i are the SU(3) coefficients with the sign convention adopted in this article [see note in the Table of SU(3) Iscoscalar Factors and Fig. 2 in the text]. M_N is the nucleon mass, M_R is the resonance mass for which Γ is calculated, k is the center-of-mass momentum for the channel being considered, and g_i are the relevent couplings. For the case of singlet–octet mixing, formula (8) has to be used in conjunction with (6) and (7). G_8 and G_1 represent the couplings for the multiplet, and Λ and Λ' represent the couplings for the physical states.

The relation between g_D, g_F. and the parameter α is

$$\alpha = \left[1 + \frac{\sqrt{5}}{3} \frac{g_F}{g_D} \right]^{-1} . \qquad (10)$$

Exact SU(3) predicts that the couplings g_i for all the members of a multiplet are the same; however, since the symmetry is broken for the masses, it is probably broken for the widths. In the case of the $3/2^+$ decuplet, for broken SU(3) sum rules have been derived by Becchi,[6] Gupta,[7] and Konuma[8] independently. The form derived by Gupta relates the g_i for the members of the decuplet by the relation

$$2(\Delta + \Xi) = 3\Sigma^*(\Lambda\pi) + \Sigma^*(\Sigma\pi), \qquad (11)$$

where $\Sigma^*(\Lambda\pi)$ is the coupling for the $\Sigma(1385) \to \Lambda\pi$ decay and $\Sigma^*(\Sigma\pi)$ is the coupling for the decay $\Sigma(1385) \to \Sigma\pi$.

As mentioned in the text (Sec. IV B) the determination of the relative signs of resonant amplitudes can be useful in making an SU(3) assignment of resonances. In fact the resonant amplitude $T \propto \sqrt{x_e x_i} \propto G_e G_i$, where the subscript e refers to the elastic channel and the G_e, G_i are the couplings of Eqs. (6) through (9). Assuming that all g_i are positive, the sign of the G_i are dependent upon the sign of the Clebsh–Gordon coefficients c_i. Once a sign convention is adopted (we use the Levi–Setti[9] convention, see Fig. 2 in the text) and the signs for a Σ state (I=1) and a Λ state (I=0) of known SU(3) assignment have been chosen for reference, the signs of all the other amplitudes can be useful in determining multiplet assignments. For exact SU(3) all the decays of members of a decuplet have the same sign. For octets the relative sign depends upon the value of g_D/g_F and the mixing angle, as seen from Eqs. (7) through (9).

Fits to the Data

Fits of baryon decay rates within SU(3) can be found in, among others, papers by Tripp,[10,11] Levi–Setti,[9] Samios,[12] and Plane.[13] The most recent fits were made by Barbaro–Galtieri[14] and Samios.[15] A fit of the decay rates within $SU(6)_w$ can be found in Litchfield et al.[16] Analysis of the baryon mass spectrum using the quark shell model has been done by Jones et al.[17] An analysis of baryon couplings in a quark model with chromodynamics has been done recently by Koniuk and Isgur.[18]

For our SU(3) analysis in fitting the data a choice for B_ℓ has to be made. Plane[13] tried two forms for B_ℓ:

(a) The form $B_\ell = (kr)^{2\ell} D_\ell(kr)$, r being the radius of interaction and D_ℓ the polynomials in kr given by Blatt and Weisskopf.[19] Usually r is taken to be 1 fermi.[10]

(b) The form $B_\ell = k^{2\ell}$.

However, for final results form (b) was chosen. A discussion of the differences among these two forms has been given by Barbaro–Galtieri.[20]. As shown in Ref. 20, not only the values of the couplings, g_i, depend upon the form used for B_ℓ, but also the value obtained for the mixing angle. For the $3/2^-$ singlet, $\Lambda(1520)$, and the isospin–0 member of the octet, $\Lambda(1690)$, the mixing angles obtained in the two cases were

$$\theta_a = (-16.1^{+1.4}_{-1.3})^\circ \ , \ \theta_b = (-27.5^{+3.6}_{-3.4})^\circ \ ,$$

in disagreement by a few standard deviations. However, if a radius of interaction of r = 0.15 fermi was used for form (a), the two values of θ agreed. This value of r does not fit resonance shapes when used in the Breit-Wigner resonant form.

Samios[15] used form (b) for B_ℓ.

Table I is a summary of the fits made by us (update of Barbaro-Galtieri[14]) using the barrier factor form (a) and exact SU(3). The values of the masses, widths, and amplitudes used in the fits are taken from this edition's Tables and Listings.

$1/2^-$ Nonet (Baryon-Eta Resonances)

For this nonet Eq. (7) was multiplied by the factor

$$\left[\frac{M_R - M_B}{\overline{M}_R - \overline{M}_B}\right]^2 ,$$

where M_B is the decay baryon and $\overline{M}_R - \overline{M}_B$=564 MeV is the difference of the mean $1/2^-$ and $1/2^+$ baryon octet masses. This kinematic factor comes from PCAC arguments (i.e., the assumption that the axial vector current remains an octet in the presence of symmetry breaking) and it was advocated by Graham.[21] For the $1/2^-$ nonet it was used in this form first by Gell-Mann.[22]

$3/2^+$ Decuplet

The agreement among the coupling constants obtained for the four rates in this decuplet is very bad. The fit made using form (a) for B_ℓ has χ^2=58 for 3 degrees of freedom; the one made with form (b) for B_ℓ has χ^2/DF=13/3. The broken SU(3) relation (11), however, is very well satisified.

B. SU(3) CLASSIFICATION OF MESON RESONANCES

All of the discussion above applies, except that for bosons the GMO formula is usually applied to the square of the masses, as opposed to the first power for fermions. Thus for example, Eq. (2) becomes

$$4\hat{K} = 3\hat{\eta} + \hat{\pi}. \qquad (2')$$

The symbol $\hat{K}$ was introduced by Glashow and Socolow[4] for the square of the K mass, etc.

Because of the difference between Eqs. (5') and (5"), there is also an extra factor of (M_N/M_R) in Eqs. (6) and (7). The three established nonets (0^-, 1^-, 2^+) and their mixing angles are listed at the bottom of the Meson Table.

Table I. SU(3) baryon multiplets with two or more known members. Values of θ and α [defined by Eqs. (8) and (10)] are the result of fits made to all the measured two-body decay rates of each mutiplet.

J^P	Octet members[a]				Singlet	θ(deg)[b]	α
$1/2^-$	N(1535)	Λ(1670)	Σ(1750)	{[Ξ(1850)] / [Ξ(1737)]}	Λ(1405)	{−2±6 / −32±6}	{0.94±.14 / 0.38±.08}[c]
$3/2^-$	N(1520)	Λ(1690)	Σ(1670)	[Ξ(1819)]	Λ(1520)	−21±3	0.32±.04
$5/2^-$	N(1670)	Λ(1830)	Σ(1765)				1.21±.04
$5/2^+$	N(1688)	Λ(1815)	Σ(1915)	[Ξ(2087)]	Λ(2110)	24±4	0.72±.02
	Decuplet members[d]				g_{10}		
$3/2^+$	Δ(1232)	Σ(1385)	Ξ(1530)	Ω^-	1.0−1.5	χ^2/DF=58/3	
$7/2^+$	Δ(1950)	Σ(2030)					

[a]Masses in parentheses are the nominal masses used in the Baryon Table. The Ξ members have masses as calculated by using formulae (1) and (2) with the mixing angle θ derived from the decay widths.
[b]See text for a discussion of the $1/2^-$ mixing angle.
[c]The first values of θ and α are obtained by using a plus sign for the amplitudes of both N(1535) → Nη and Λ(1670) → Λη. The second values use a minus sign for the second amplitude. Both fits, however, have a bad χ^2, mostly due to the two baryon−η amplitudes.
[d]Coupling constants updated from Ref. 14, using new Ξ(1530) data.

References

1. R. H. Dalitz, in Fundamentals of Quark Models (Proceedings of the 17th Scottish Universities Summer School in Physics, St. Andrews, August 1976), edited by I. M. Barbour and A. T. Davies, pg. 151.
2. M. Gell-Mann, Phys. Rev. 125, 1067 (1962); S. Okubo, Prog. Theor. Phys. (Kyoto) 27, 949 (1962).
3. J. J. Sakurai, Phys. Rev. Letters 9, 472 (1962).
4. The formula has been calculated from analogy with the formula for mixing of meson states, first put in this form by S. L. Glashow and R. H. Socolow, Phys. Rev. Letters 15, 329 (1966).
5. See. R. P. Feynman, Theory of Fundamental Processes, W. A. Benjamin, Inc., New York, 1962.
6. C. Becchi, E. Eberle, and G. Morpurgo, Phys Rev. 136B, 808 (1964).
7. V. Gupta and V. Singh, Phys. Rev. 135B, 1442 (1964).
8. M. Konuma and Y. Tomozawa, Phys. Lett. 10, 347 (1964).
9. R. Levi-Setti, in Proceedings of the Lund International Conference on Elementary Particles, Lund, 1969.
10. R. D. Tripp, in Proceedings of the 14th International Conference on High Energy Physics, Vienna, 1968, p. 173.
11. R. D. Tripp, in Proceedings of the 3rd Hawaiian Topical Conference on Particle Physics; UCRL-19361 (1969).
12. N. P. Samios, in Proceedings of the 15th International Conference on High Energy Physics, Kiev, 1970, p. 187.
13. D. E. Plane et al., Nuclear Physics B22, 93 (1970). Also J. Meyer and D. E. Plane, Nuclear Physics B25, 428 (1971).
14. A. Barbaro-Galtieri, LBL-1366 and in Proceedings of the 16th International Conference on High Energy Physics, National Accelerator Laboratory, Vol. 1, page 159 (1972).
15. N. P. Samios, M. Goldberg, and B. T. Meadows in Hadrons and SU(3): A Critical Review, BNL Report BNL-17851 (1973).
16. P. J. Litchfield, R. J. Cashmore, and A. J. G. Hey in Proceedings of the Topical Conference on Baryon Resonances (Oxford, 1976), edited by R. T. Ross and D. H. Saxon, pg. 477.
17. M. Jones, R. H. Dalitz, and R. R. Horgan, Nucl. Phys. B129, 45 (1977).
18. R. Koniuk and N. Isgur, "Baryon Decays in a Quark Model with Chromodynamics", University of Toronto preprint, November 1979.
19. J. M. Blatt and V. F. Weisskopf, Theoretical Nuclear Physics, Wiley, New York, 1952.
20. A. Barbaro-Galtieri, in Properties of Fundamental Interactions, Erice, July 8-26, 1971, edited by A. Zichichi, Editrice Compositori, page 533 (1973).
21. R. Graham, S. Pakvasa, and K. Raman, Phys. Rev. 163, 1774 (1967).
22. M. Gell-Mann, R. Oakes, and B. Renner, Phys. Rev. 175, 2195 (1968).

Appendix IV

GROWTH OF INFORMATION

From time to time we have presented figures demonstrating the amount of experimental work which has gone into spectroscopy, and the amount of new information available as a result. The 1980 versions of these figures are shown as Figs. 1 and 2.

Figure 1 is a simple count of the number of meson resonances listed in the Tables, categorized as those "understood" -- i.e., all quantum numbers are believed known -- and those simply "listed". The rapid recent increase in both of these categories occurred because of the discovery of the J/ψ and related particles.

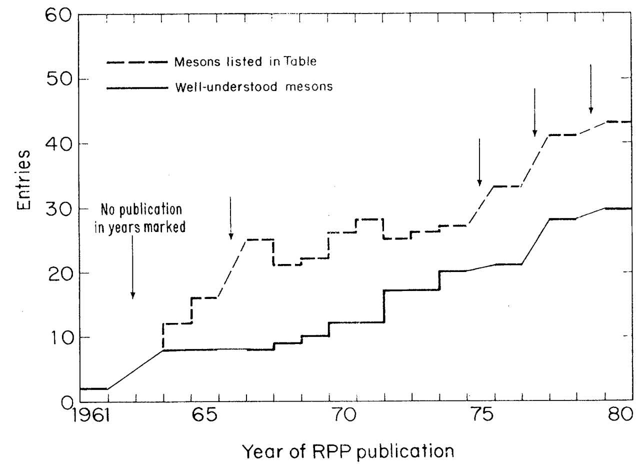

Fig. 1. Number of meson resonances listed in the Tables (dashed line) and those for which all quantum numbers are known (solid line), as a function of year of publication of the Review of Particle Properties.

In Figure 2 we present similar information for the baryon resonances, but concentrate here on the "growth of understanding". That is, the number of known baryons (we include for this figure only those with known J^P) has grown only very slowly with time (dashed line); the real progress has been in the measurement of the properties of those baryons. Therefore we show as the solid line a count of the number of baryonic properties -- mass, width, and branching ratios. Most of these results are from partial-wave analyses.

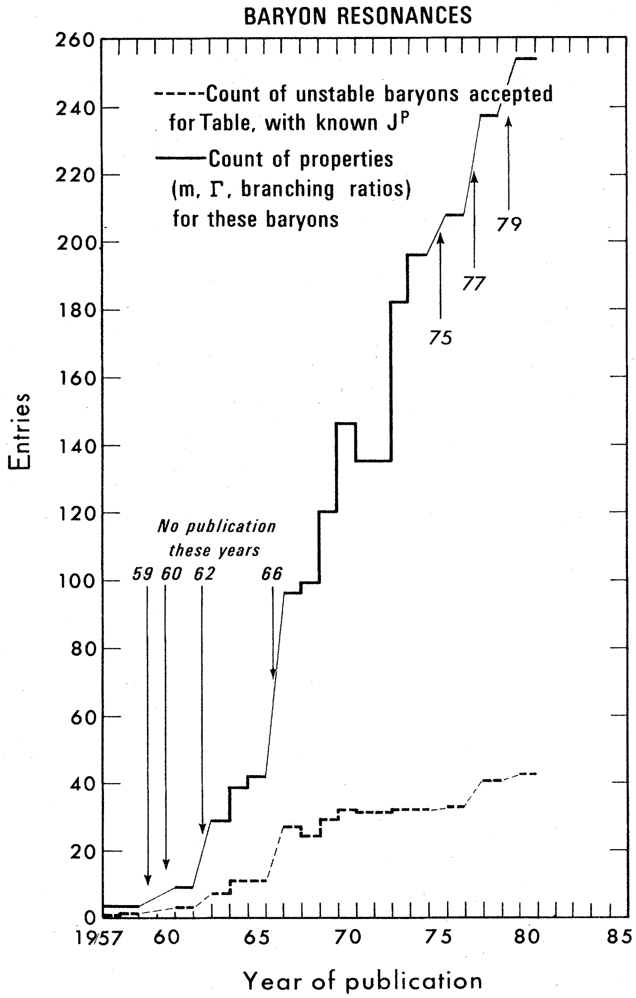

Fig. 2. Total amount of information (mass + width + branching ratios) on baryon resonances listed in the Tables, restricted to those with well-established J^P (solid line). Dashed line shows numbers of such resonances listed. Abscissa shows year of publication of Review of Particle Properties.

A history of the values of some of the constants in the Review of Particle Properties is presented in Figs. 3–7. It may be said that one can estimate the age of a high energy physicist by asking him or her the mass of the Λ. If the answer is 1115.44 MeV, he probably was deep into his graduate training in 1965.

A history of this sort has more than whimsical value. We may use it as a guide to develop a "feel" for the reliability of current values. In Fig. 3 we show how the generally accepted values for the speed of light and a couple of other constants have changed with time. The "generally accepted value" is usually an average over several experiments, performed by a compiler (in Fig. 3, the compiler is other than the Particle Data Group in all cases, although we do quote the compiled results). The abscissa on all these figures is the date of publication of the value shown. Clearly there is a general progression toward better understanding -- at least as measured by the size of the error bars. However, the size of the error bars does not tell the full story, as we can see by the frequency with which the "best" value has changed by more than one standard deviation. Changes in these values can come from several sources: a new experimental measurement, re-evaluation of an old measurement (which can come about if a previously unrecognized source of bias is discovered and corrected, or if a new value for one of the input constants, e.g. the electric charge, is available), or a change in the averaging procedure.

In Fig. 4 we show the history of some masses (including the Λ, for radioactive Λ dating of your colleagues), based on averages which we ourselves performed. These are adapted from those originally presented by Rosenfeld[1] in 1975. The publication date refers to the publication of the Review of Particle Properties.

In Fig. 5 we show the best estimates for the lifetimes of some of the particles stable against strong decay. These and subsequent figures have been compiled since publication of the Rosenfeld article.[1] In Fig. 6 we show the widths of some of the resonances, and in Fig. 7, the values of some of the branching fractions. All values are taken from the Tables. Before 1964, very few branching fractions were listed in the Tables. In all cases, a representative sample is chosen, usually from those with a lot of activity (a limited number of special requests for a more complete set of such figures may be honored, for those seriously interested in the history of the "best" values of physical constants). In each figure, the heavy inner error bar represents the statistical error computed in the averaging procedure, and the thin outer error bars, when present, indicate the increase in the error due to the "scale factor". The scale factor is described in the introductory text, Sec. VII. It represents an attempt to quantify the increase in the uncertainty which is present in the case of experiments which disagree by more than a certain amount. In the case where the error represents an "educated guess," rather than a calculation, the inner error bar is absent.

On the whole, the number of times the values have changed by more than one standard deviation over the years is remarkably few. Even those branching fractions which involve rare decays and which are therefore presumably difficult to measure (Fig. 7) are, for the most part, within one or two standard deviations in 1978 of their value in any year since 1960. This is in spite of the vast amount of new experimental input, and indicates the general reliability of the results.

Of course, the data points for a given quantity are hardly independent of each other, but those differing by several years frequently have quite different experimental input. The relative lack of change is a comment both on the experiments and on the averaging procedures. We, of course, are responsible only for the averages (except Fig. 3). These averages entail considerable exercise of judgment: there are conflicting experiments, experiments with impossibly small errors, "preliminary" results, and so forth. Statistical procedures will tell us that two experiments do not agree; they do not give a clue as to which (if either) is a good representation of the truth.

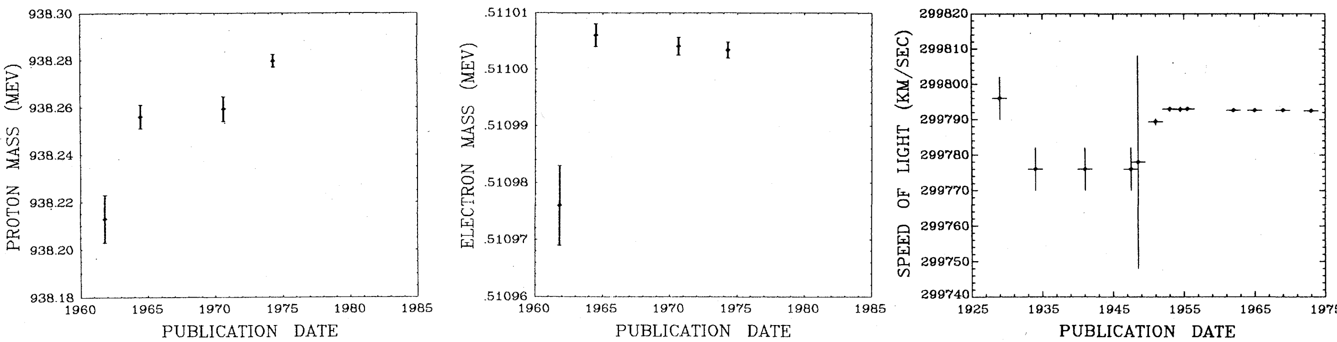

Fig. 3. The "generally accepted values" of the proton mass, the electron mass, and the speed of light, as a function of the publication date of the compilation used (not done by the Particle Data Group). Data for the speed of light plot courtesy of E. R. Cohen, Rockwell International Science Center. See the Stable Particle Data Card Listings for references on proton and electron masses.

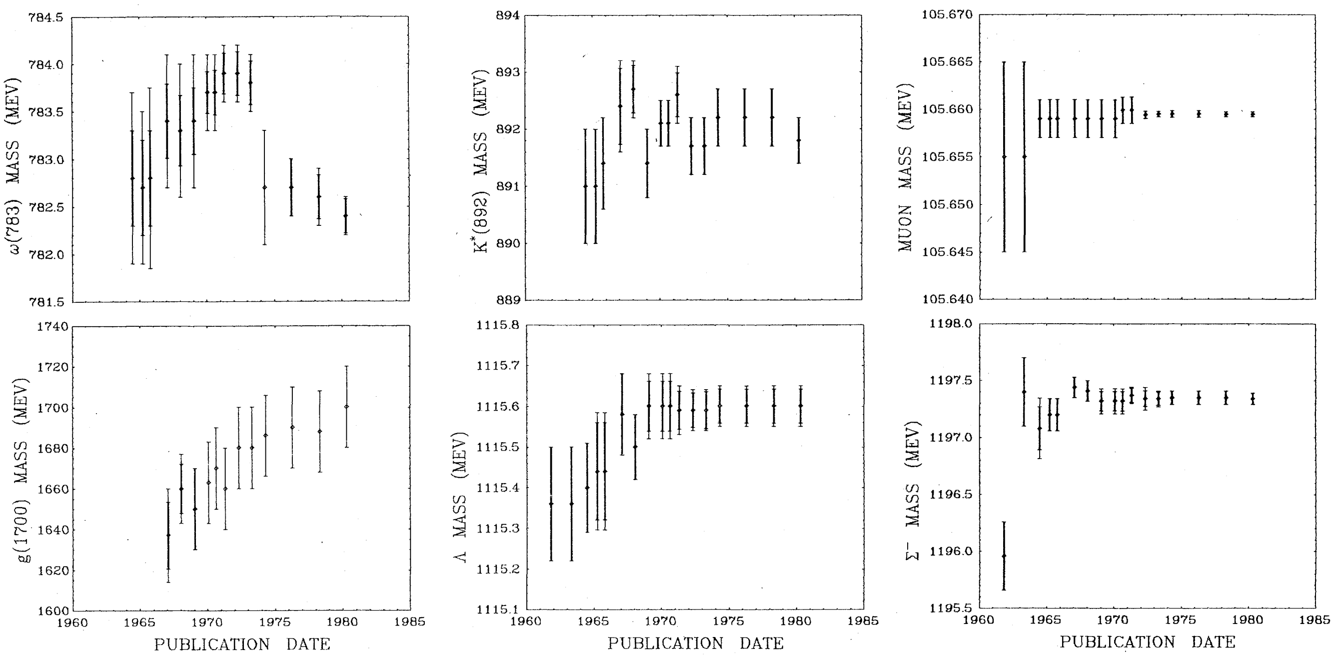

Fig. 4. Particle Data Group averages of the masses of various particles, as a function of date of publication of Review of Particle Properties (Adapted, with permission, from *Annual Review of Nuclear Science*, Volume 25. Copyright 1975 by Annual Reviews, Inc. All rights reserved). Full error bar indicates quoted error; thick-lined portion indicates quoted error with "scale factor" removed (see Sec. VII of introductory text).

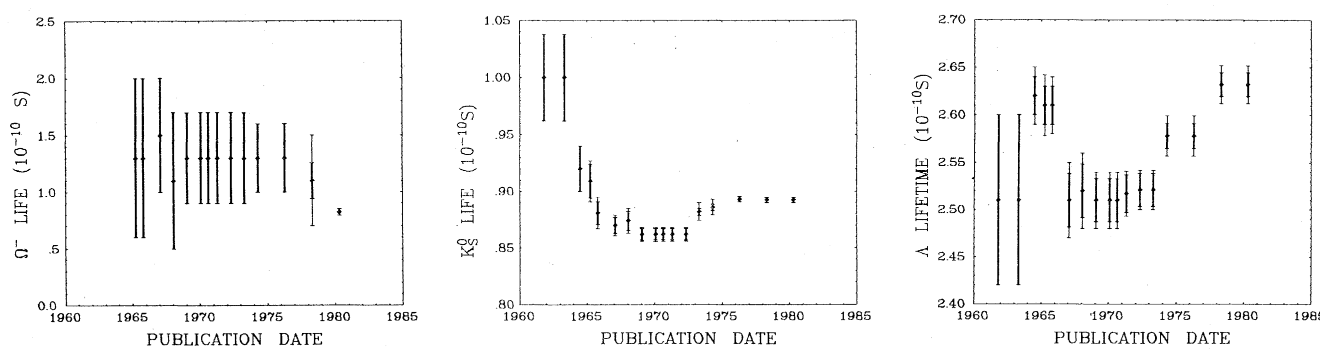

Fig. 5. Particle Data Group averages of the lifetimes of various particles, as a function of publication date of RPP.

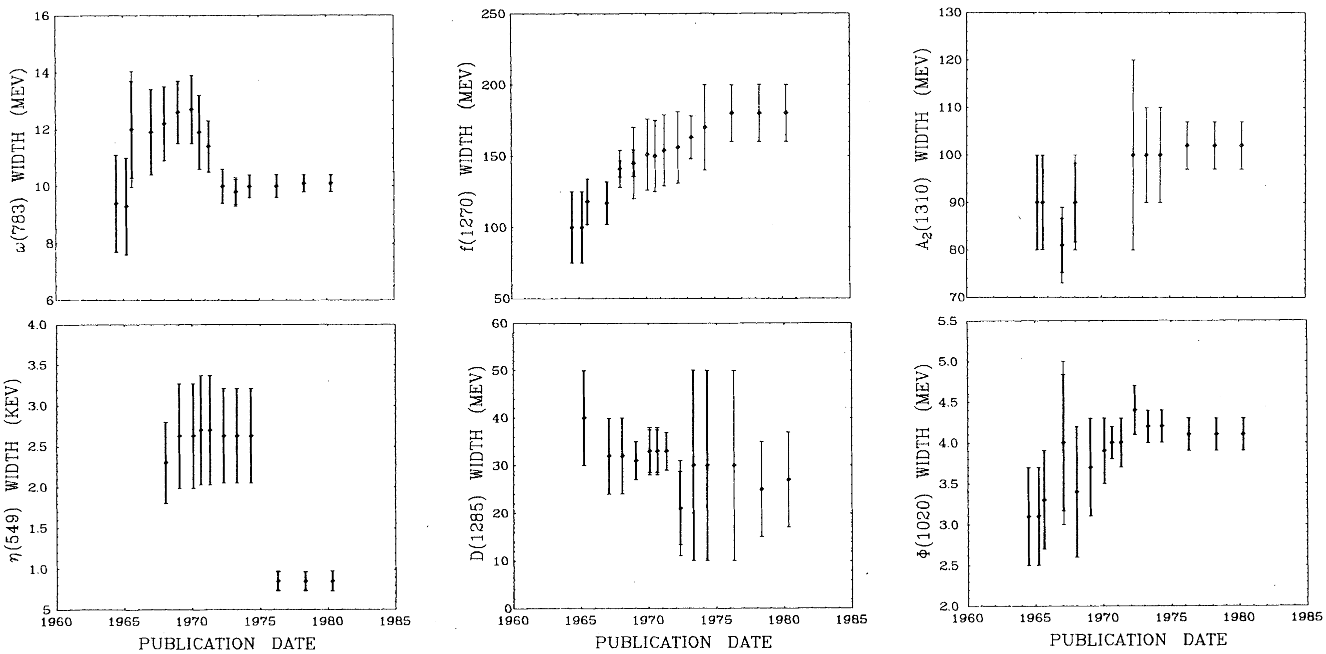

Fig. 6. Particle Data Group averages of the widths of various resonances, as a function of date of publication of RPP. The gap in the A_2 data indicates the years when the A_2 was thought to be split.

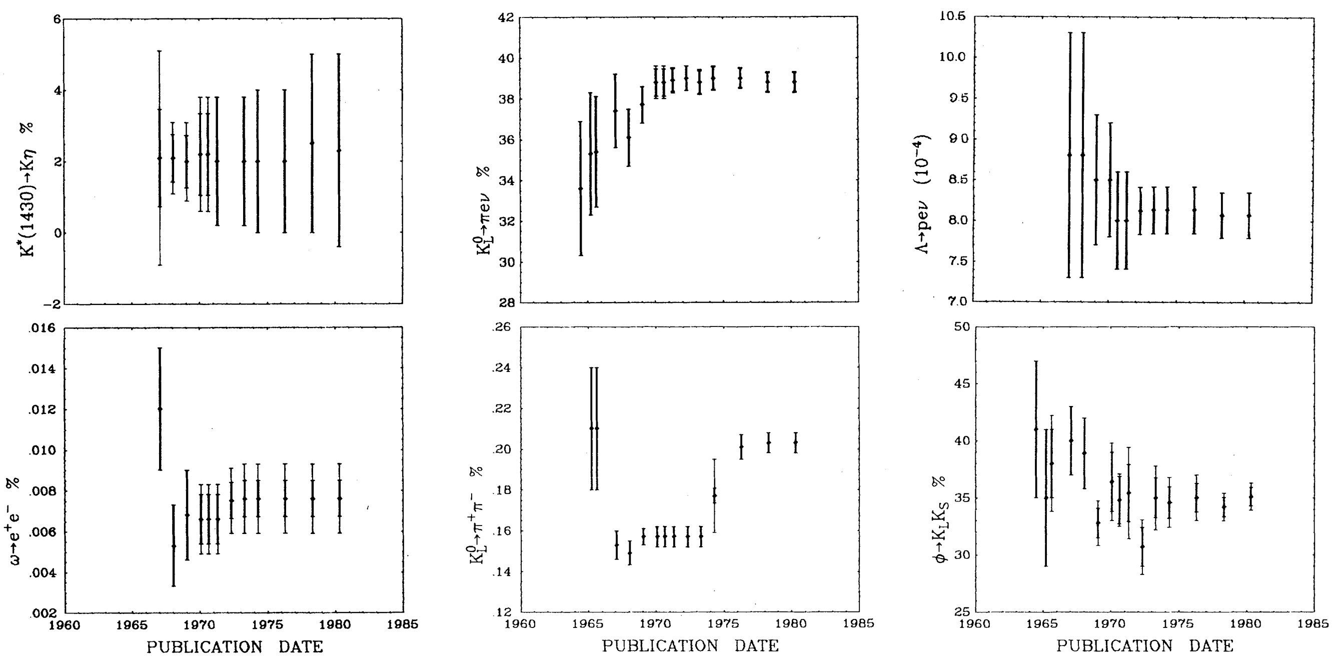

Fig. 7. Particle Data Group averages of various branching fractions, as a function of date of publication of RPP.

Major decisions, and their motivations, are usually discussed on a case–by–case basis in the Data Card Listings; general comments may be found in Sec. II of the text and in Rosenfeld[1]. Note that, occasionally, the error bars increase from one publication to the next. This is usually the result of decision making by the compiler, e.g., to cease using a particular result, or because of new results in poor agreement with the old results.

We show these figures not only to demonstrate that there is not much change in these averages in the usual case, but also to show that there exist cases with relatively large changes. There is a psychological danger in preparing tables of "right" answers. The old joke about the experimenter who fights the systematics until he or she gets the "right" answer (read "agrees with previous experiments"), and then publishes, contains a germ of truth (presumably, those who compile and average experimental results are also not immune to this disease). A result can disagree with the average of all previous experiments by five standard deviations, and still be right! Hence, perhaps it is of value to show that large changes can (and do) sometimes occur.

Reference

1. A. H. Rosenfeld, Ann. Rev. Nucl. Sci. 25, 555 (1975).