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Review of Particle Properties
Particle Data Group

THOMAS A. LASINSKI, ANGELA BARBARO-GALTIERI, ROBERT L. KELLY, ALAN RITTENBERG, ARTHUR H. ROSENFELD, and THOMAS G. TRIPPE
Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720*
NAOMI BARASH-SCHMIDT
Brandeis University, Waltham, Massachusetts 02154
CLAUDE BRICMAN and VLADIMIR CHALOUPKA
CERN, 1211 Genève 23, Switzerland
PAUL SÖDING
DESY, 2000 Hamburg 52, Germany
MATTS ROOS
Department of Nuclear Physics, University of Helsinki, Helsinki 17, Finland

This review of the properties of leptons, mesons, and baryons is an updating of Review of Particle Properties, Particle Data Group (Phys. Letters **39B**, No. 1 (1972)). Data are evaluated, listed, averaged, and summarized in tables. A data booklet is also available.

CONTENTS

I. INTRODUCTION, CREDITS, CONSULTANTS

This review is an updating through January 1973 of our previous review (Particle Data Group, 1972). In this version of the text we concentrate on topics that are either new or essential. For complementary information on our standard procedures the reader is referred

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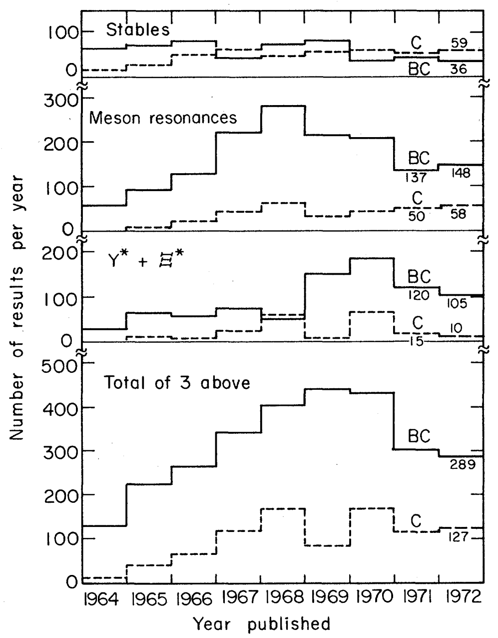

FIG. 1. Statistics on the rate of production of data on particle properties. From the top to the bottom, the number of results per year are presented for stable particles, meson resonances, $Y^*+\Xi^*$'s, and the total of the three above. The full lines correspond to bubble-chamber techniques (BC) and interrupted lines correspond to counters, spark chambers and spectrometers (C). Note that the figure omits N^* and Z^*, the field where counters have overwhelmed bubble chambers, because we punch mainly results from partial wave analyses instead of primary data.

to our January 1970 article (Particle Data Group, 1970).

Again 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. Only then is it appropriate to state "average value obtained from Rev. Mod. Phys. **45,** No. 2, S1 (1973)." If the list of experiments is so long that this is impractical, we suggest the form: Jones *et al.* 70, Smith *et al.* 69, ··· average value and complete references in *Review of* ···.

The responsibilities of the authors of this compilation can roughly be broken down as follows:

(1) *Stable particles:* A. Barbaro-Galtieri, N. Barash-Schmidt, and T. G. Trippe.

(2) *Meson resonances:* V. Chaloupka, M. Roos, A. H. Rosenfeld, and P. Söding.

(3) *Baryon resonances:* A. Barbaro-Galtieri, C. Bricman, R. L. Kelly, and T. A. Lasinski.

General: All Berkeley authors.

Consultants: The three teams just mentioned must come to a consensus on how to treat the data and must write a number of mini-reviews. It is impractical to spread this responsibility over more than a few people in each team and still expect to meet publication deadlines. Hence we limit our number of authors (to eleven in this edition), but thereby leave gaps in our coverage, both intellectual and geographical. To help us overcome this deficiency, we have solicited the help of consultants:

- Stanley J. Brodsky (Stanford Linear Accelerator Center)
- Chih-Yung Chien (Johns Hopkins University)
- Anatoli Kuznetsov (JINR, Dubna), starting 1973
- R. Gordon Moorhouse (University of Glasgow)
- Horst Oberlack (Lawrence Berkeley Laboratory)
- Oliver E. Overseth (University of Michigan)
- LeRoy R. Price (University of California at Irvine)
- Mark Sakitt (Brookhaven National Laboratory).

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

II. COLLECTION AND TREATMENT OF DATA

A. Annual Growth of Data

Figure 1 shows the rate at which we have been recording results, as a function of year published. Through 1969 we subdivided our annual count into two parts:

(1) Highest quality data. These are the results that we accept for averaging and fitting.

(2) Lesser quality data; results which, for one of the reasons mentioned in Section B, below, we encoded but did not accept for averaging.

We have found that this subdivision stays at a fairly constant 60:40 ratio, and is not otherwise very informative, so we now merely count the total.

We see that the number of results per year from bubble chambers, though still dominant, is now dropping; that from counters is roughly constant.

It is of interest to compare the declining rate at which bubble chambers produce results on particle properties with the fact that the number of bubble chamber events measured each year is roughly constant. Apparently experiments have become larger and more specialized, and we now find ourselves encoding more density matrix elements for our compilations of cross sections, and fewer masses and widths of bumps.

It is of interest to compare the decreasing total rate at which we encode data on particle properties with the fact that the rate of publication of experimental papers is about constant. Some differences are that many new experiments are above the resonance region, there are many photon and electron experiments, and many studies of inclusive reactions. Again, compilers are flooded with new data, but the great majority go into collections of cross sections.

B. 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
(2) Meson resonances
(3) Baryon resonances

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 (February 1, 1973) for all journals listed in the Illustrative Key. We also include preprints and unpublished conference reports which have come to our attention, but make no attempt at completeness.

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

- The quantity 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 we have corresponded with 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.
- Two or more experiments give contradictory results, so that it is senseless to average the data.

When the data for a particle have received special treatment or when they 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 therefore encouraged to familiarize himself with the Data Card Listings and, ultimately, with the original experiments.

III. CRITERIA FOR RESONANCES

An experimentalist who finds some evidence for a peak in a mass spectrum 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 any substantial claim or evidence for a new state.

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 $\gtrsim 90\%$ chance of survival. One's betting odds for survival are of course completely subjective; they are influenced mainly by the amount of information available (such as partial-wave analyses) and somewhat by the degree of controversy over interpretation and how long it will be before more information is available. An arrow ($\rightarrow$) 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.

More details on our acceptance criteria are as follows.

1. Partial Wave Analyses

(a) In those cases where 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 left-hand 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 K^+p peak (near $K\Delta$ threshold) called $Z_1(1900)$, which is discussed in a mini-review in the Baryon Data Card Listings. K^+p P_{13} Argand plots are displayed there, and most suggest a resonance; however, there is disagreement between the various analyses as to the speed of the amplitude, i.e., as to whether it has a Breit-Wigner type of behavior. In addition the errors on the amplitudes are still large, and we prefer to wait a bit longer before we put Z_1 in the Baryon Table.

(b) Often where there are insufficient data to perform energy-independent analyses, one 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 ($\bar{K}N \rightarrow \bar{K}N$, $\pi\Sigma$, etc.), before putting the claim in the table.

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

2. *"Bumps"*

This category includes most mesons, Ξ^* peaks, and the higher mass ($\gtrsim 2300$ MeV) N^*, Y^* peaks. Unless the peak is experimentally shaky, we put it in the table. Thus we accept peaks of high statistical significance or states that are observed via several different production processes.

3. *"Diffractive Mesons"*

(a) This category includes statistically significant peaks like A_1, A_3, or Q, which are not far above the $\rho\pi$, $f\pi$, or $K^*\pi$ thresholds. Although the threshold behavior in these channels may be described by the "Deck effect" or by its modern version "double Regge-pole exchange", the question of resonance interpretation has for some time been open. Several years ago we put these peaks into the Meson Table, but warned the reader not to conclude that we claim they are necessarily genuine resonances. However, if such effects can be convincingly associated with poles of the S-matrix on some unphysical sheet, we shall call them resonances (see, e.g., Chew, 1968).

(b) Recently Ascoli and collaborators (Ascoli, 1972) have attempted partial-wave analyses of the $\pi\pi\pi$ system in reactions like $\pi N \rightarrow (\pi\pi\pi)N$. There are several important aspects to such analyses:

(i) for a given t, the $\pi\pi\pi$ vertex is assumed to be independent of the NN vertex;

(ii) the $\pi\pi\pi$ reaction is assumed to proceed through quasi-two-body states ($\rho\pi$, $\epsilon\pi$, etc.) in the spirit of the isobar model;

(iii) in order to keep the number of parameters manageable, certain plausible assumptions are made on the vanishing of some of the spin density matrix elements of the ($\pi\pi\pi$) system.

In view of the novelty and difficulty of this analysis, we are reluctant to place these partial-wave analyses in the same category as 1(c) above. However, through such an analysis, the already significant A_2 peak has been confirmed to be a Breit–Wigner type resonance through an observed phase change of 90° relative to other slowly varying partial waves. In contrast, peaks like A_1 and A_3 show an enhancement in a now "pure" J^P mass plot but reveal *no* relative 90° phase change. While this observation suggests that the A_1 and A_3 are not resonances, a mechanism has been suggested by Wright (1972) that reproduces the A_1 "partial wave" and still associates the A_1 with a pole on an unphysical sheet. In the sense of Chew 68, the A_1 may still be called a resonance.

We now ask "How likely is it that peaks of class 2 and 3(a) above (not checked by partial-wave analysis) will eventually be confirmed as resonances?" We know of no experimentally convincing peak that has been shown to have *nothing* to do with a resonance. But be warned that broad peaks may be misleading: they may contain several resonances, or they may include a resonance narrower than the peak, plus some other complications; for example:

- Before 1966 we might have tabulated the πp bumps at 1520 and 1688 MeV as single resonances, whereas partial-wave analysis shows that each contains several resonances.
- Before the $N'(1470, P_{11})$ was confirmed in partial-wave analyses, it was seen as a missing mass or $p\pi\pi$ peak produced peripherally in high-energy pp collisions, and (like A_1, Q, and A_3) was partly explained by the Deck effect and later by double-Regge-pole exchange.

In summary, we enter into the Tables of Particle Properties experimentally convincing peaks unless there is contradictory information; and we expect that most of these peaks will eventually be confirmed as one or more resonances.

IV. PARAMETERS AND CONVENTIONS

A. Quantum Numbers

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

I = isospin
G = G-parity
J = spin
P = space parity
C = charge conjugation parity.

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 extension G which has eigenvalues for charged states too. It is usually[1] defined by

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

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[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).

A neutral nonstrange 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 the 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., $\bar{q}q$, 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 in Eq. (2)] is

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

Equations (2) and (3) combine to give

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

The parity is

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

Equations (3) and (5) combine to give

$$C_nP=-(-1)^S \tag{5b}$$

so all singlet ($^1S_0$, $^1P_1$, $\cdots$) have $C_nP=-1$, and all triplets ($^3S_1$, $\cdots$) 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 (5)!] apply *unchanged*. Of course the mesons are usually spinless and S is zero, but the equations are more general. Equations (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" mesons, i.e. mesons that cannot be composed of $\bar{q}q$.

The unitary triplets 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 unitary octets and singlets. The non-observation of "exotic" mesons (i.e. mesons in more complicated supermultiplets) is of course one of the bases of the quark model. But it is slightly less obvious that even some *octets* are forbidden by the model, for example those with $(J^P)C_n=(1^-)-$, $(2^+)-$, $\cdots$. Such states are also not observed, and this is an additional piece of evidence for the quark model.

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

The top part of Table I 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 $^3D_2$, $^1D_2$. 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. (5.1) 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.

Baryons and Mesons

Well-established quantum numbers are underlined (except for stable particles, where most of the quantum numbers are established). We have used flimsy evidence to guess many of the remaining ones, and we have indicated with "?" the ones 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 hypercharge Y, and, for a nonstrange meson, its G parity. For convenience, we also list the strangeness S, which is related to Y and B by

$$S=Y-B.$$

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

To crowd even more information onto the symbol, we sometimes add a subscript giving J^P. If J^P is not known, but must be "Normal" (0^+, 1^-, 2^+, $\cdots$), e.g., because $K\pi$ decays are seen, we use the subscript N. Thus $K_N(1420)$. If such modes are *not* seen (and are not otherwise forbidden), we *guess* that it is because J is "Abnormal", and we write, for example, $K_A(1240)$.

For *baryons* ($B=1$) no attempt has been made to attach a subscript about J and P. The name conventions for baryons are given in the second part of table 2. For stable baryons of each I and Y 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},

Table I. $I^G(J^P)$ of mesons from $\bar{q}q$ model. For the distinction between abnormal J^P and abnormal C, see text below Eq. (5). K mesons share the same values of J^P as the I = 0 and 1 states shown, but are not eigenstates of G. The middle column, which gathers together $(J^P)_{\boxed{\text{N or A}}}$ CP, is a redundant intermediate step intended to make the table easier to read.

	$\bar{q}q$ State CP −	 CP +	$(J^P)_{\square}$ CP Normal or abnormal	$I^G(J^P)C_n$	Examples and comments
Parity −	$^1S_0$		$(0^-)_A-$	$0^+(0^-)+$	η, η'
				$1^-(0^-)+$	π
		$^3S_1$	$(1^-)_N+$	$0^-(1^-)-$	ω, ϕ
				$1^+(1^-)-$	ρ
Parity +	$^1P_1$		$(1^+)_A-$	$0^-(1^+)-$	
				$1^+(1^+)-$	B
		$^3P_0$	$(0^+)_N+$	$0^+(0^+)+$	ϵ, S*
				$1^-(0^+)+$	$\pi_N(1016)$
		$^3P_1$	$(1^+)_A+$	$0^+(1^+)+$	
				$1^-(1^+)+$	A1
		$^3P_2$	$(2^+)_N+$	$0^+(2^+)+$	f, f'
				$1^-(2^+)+$	A2
Parity −	$^1D_2$		$(2^-)_A-$	$0^+(2^-)+$	Regge recurrence of $^1S_0$, 0^-
				$1^-(2^-)+$	
		$^3D_1$	$(1^-)_N+$	same as $^3S_1$	
		$^3D_2$	$(2^-)_A+$	$0^-(2^-)-$	Regge recurrence of top abnormal-C state below: $(J^P)C_n = (0^-)-$
				$1^+(2^-)-$	
		$^3D_3$	$(3^-)_N+$	$J > 2$	
Parity +	$^1F_3$		$(3^+)_A-$	$J > 2$	
		$^3F_2$	$(2^+)_N+$	same as $^3P_2$	
		$^3F_3$	$(3^+)_A+$	$J > 2$	
		$^3F_4$	$(4^+)_N+$	etc.	

ABNORMAL C STATES THAT CANNOT COME FROM $\bar{q}q$ MODEL

Abnormal C states Have no $\bar{q}q$ model	$(0^-)_A+$	$0^-(0^-)-$	All except $J^P = 0^-$ are J^P = normal, CP = −1
		$1^+(0^-)-$	
	$(1^-)_N-$	$0^+(1^-)+$	
		$1^-(1^-)+$	
	$(0^+)_N-$	$0^-(0^+)-$	
		$1^+(0^+)-$	
	$(2^+)_N-$	$0^-(2^+)-$	
		$1^+(2^+)-$	
	$(3^-)_N-$	$0^+(3^-)+$	
		$1^-(3^-)+$	

TABLE II. Particle name conventions.

Name	I	Y	S	G
		Mesons		
η	0	0	0	+
ω or ϕ[a]	0	0	0	−
ρ	1	0	0	+
π	1	0	0	−
K^+, K^0	$\frac{1}{2}$	+1	+1	
K^-, $\bar{K}^0$	$\frac{1}{2}$	−1	−1	
		Baryons		
N	$\frac{1}{2}$	+1	0	
Δ	$\frac{3}{2}$	+1	0	
Z_0, Z_1	0, 1	+2	+1	
Λ	0	0	−1	
Σ	1	0	−1	
Ξ	$\frac{1}{2}$	−1	−2	
Ω	0	−2	−3	

[a] Starting in 1973, we use the symbol ω for those $I^G=0^-$ mesons that decay mainly into $3\pi[\omega(784),\ \omega(1675)]$; we reserve the symbol ϕ for $\phi(1019)$ and possible future higher-mass $I^G=0^-$ mesons that decay mainly into $K\bar{K}$.

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 *baryons* have identical quantum numbers we warn the reader by adding a *prime* to the symbol for the heavier one, e.g., p, $N'(1470, \frac{1}{2}^+)$. In the case of baryon resonances described by Argand diagrams which exhibit more than one resonance, we use one prime for the first, two for the second, ···; thus the series of which the proton is the stable member becomes: p, $N'(1470, \frac{1}{2}^+)$, $N''(1780, \frac{1}{2}^+)$.

If there is only one resonance on an Argand plot, and thus no need for distinctions, we use no primes.

For *some* pairs of *mesons* with supposedly identical quantum numbers, we also use primes; e.g., η, η'; f, f'.

C. Masses and Widths

An unstable particle of mass M, decaying with a mean life τ, has a wave function

$$\psi(t) \propto \exp\{-i\omega t - t/2\tau\} = \exp\{-(i/\hbar)(M - i\tfrac{1}{2}\Gamma)t\},$$

where $\Gamma=\hbar/\tau$. Its Fourier transform is

$$\psi(m) \propto 1/(M-m-\tfrac{1}{2}i\Gamma)$$

which we call a nonrelativistic Breit–Wigner resonance.

For the metastable particles in the Stable Particle Table, we tabulate τ, but for resonances which decay by the strong interaction, we tabulate Γ, which is the full width at half-maximum of $|\psi(m)|^2$.

In practice, values of M and Γ are extracted from data via *models*, and we cannot average these values if the models are dissimilar. In the next few paragraphs we discuss this point in slightly more detail, using the example of an s-channel resonance.

An *elastic* nonrelativistic Breit–Wigner T-matrix element is usually written

$$T_{11} = \tfrac{1}{2}\Gamma/(M-m-\tfrac{1}{2}i\Gamma). \qquad (6)$$

Here $\Gamma(m)$ is the width for decay into the channel 1, with angular momentum l. It contains barrier-penetration factors which can vary rapidly with energy; near threshold, $\Gamma(m)$ should start up as q^{2l+1}, and then level off. Various m dependences are used, mostly variants of the general form

$$\Gamma(m) \propto [q^2/\{1+(qR)^2\}]^l q. \qquad (7)$$

For a choice of forms, see Jackson (1964), Pišut and Roos (1968), and Barbaro–Galtieri (1968). Of course the detailed shape of the amplitude and also the value of Γ will depend slightly on the form chosen.

The width is also related to the behavior of T at resonance. It is easy to show (Herndon *et al.*, 1970) that, ignoring terms in $d\Gamma/dm$,

$$\text{“Speed”(res)} = |\,dT/dm\,|_{m=M} = x_e/(\tfrac{1}{2}\Gamma(M)), \qquad (8)$$

where the elasticity, $x_e=\Gamma_e/\Gamma$, is introduced next. More detailed properties of “Speed” are discussed in the baryon mini-review at the front of the Baryon Data Card Listings of our April 1971 edition (Particle Data Group, 1971).

For an *inelastic* resonance feeding into channel β,

$$T_{1\beta} = \tfrac{1}{2}(\Gamma_1\Gamma_\beta)^{1/2}/(M-m-\tfrac{1}{2}i\Gamma) = (x_1x_\beta)^{1/2} \times[\tfrac{1}{2}\Gamma/(M-m-\tfrac{1}{2}i\Gamma)], \qquad (9)$$

where

$$\Gamma = \sum_1^N \Gamma_\beta, \qquad x_\beta = \Gamma_\beta/\Gamma, \qquad (10)$$

and x_1 (called the elasticity) is often written x_e. (Note that in the Data Card Listings we use the symbol P_β rather than x_β.)

The channel cross section $\sigma_{1\beta}$ for the reaction $1\to\beta$ is

$$\sigma_{1\beta} = 4\pi\lambda\!\!\!^{-2}(J+\tfrac{1}{2})\,|\,T_{1\beta}\,|^2, \qquad (11)$$

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

Resonances seen in production are even more complicated. Here $\Gamma_1^{1/2}$ disappears from T, and must be replaced with some model-dependent parametrization of the production process.

In conclusion, we have seen that because of the energy dependence of Γ even the amplitude T for a resonance does not have a full-width at half-maximum equal to Γ (but it does peak at or near M). Then kinematic factors enter into the cross section for

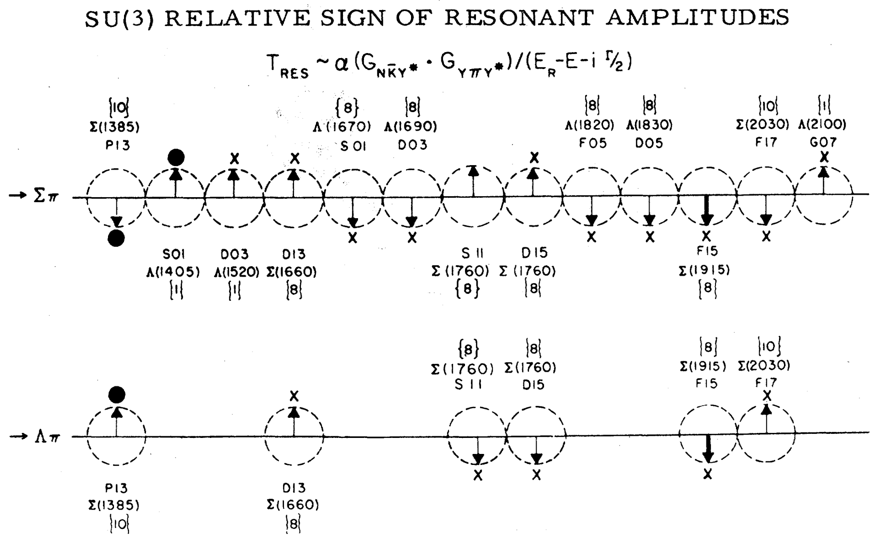

FIG. 2. Plot adapted from Levi Setti (1969) showing the sign convention adopted here for the $\Sigma\pi$ and $\Lambda\pi$ amplitudes. Once the signs of one $I=0$ and one $I=1$ amplitude are fixed, the others can be measured relative to these two. Arrows here indicate signs predicted by $SU(3)$; × marks 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.

formation [Eq. (11)] or production, and displace the observed peak away from M. For quantitative examples, see Barbaro–Galtieri (1968).

Most of the useful information on the N, Δ, Λ, and Σ *baryon resonances* with $M<2000$ MeV has come from partial-wave analysis. Masses and widths of most of these states are dependent on the model, as well as on the data used by the different groups that performed these analyses; therefore, the masses in the Baryon Table are not averages, but plausible guesses, and the errors are "external errors" based on the consistency among different analyses. For the procedures adopted, different from resonance to resonance, see the appropriate mini-review in the Data Card Listings. *Resonances* with mass $M>2000$ MeV have been detected primarily in total-cross-section experiments.

We can use Eq. (11) to relate the height of the peak at resonance σ_{res} to the elasticity x_e. At resonance the *channel* cross section is

$$\sigma_{\text{res}}(1\rightarrow\beta) = 4\pi\lambda\!\!\!^{-2}(J+\tfrac{1}{2})x_e x_\beta \tag{12}$$

and the *total* cross section is

$$\sigma_{\text{res}}(\text{total}) = 4\pi\lambda\!\!\!^{-2}(J+\tfrac{1}{2})x_e. \tag{13}$$

If J is known, we can solve for x_e. If J is not known, the product $(J+\frac{1}{2})x_e$ is given in the Baryon Table.

Starting this year we give information in the Baryon Table relating to the photon couplings of N and Δ resonances. One of the mini-reviews on N's and Δ's in the Baryon Data Card Listings contains a discussion of these couplings.

D. $SU(3)$ Sign Conventions for Λ and Σ Resonances

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 [Eq. (9)] amplitude for such a resonance will go as

$$T_{1\beta} \propto G_1 G_\beta/(M-m-\tfrac{1}{2}i\Gamma),$$

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 $SU(3)$ assignments of Λ and Σ resonances. See Appendix II for further details.

In the Data Card Listings for Λ and Σ resonances, we tabulate measured values for $(x_1x_\beta)^{1/2}\propto G_1G_\beta$. Whenever there is an explicit sign, it will be according to the convention advocated by Levi Setti (1969) and used in the table of $SU(3)$ Isoscalar Factors presented in this review. This convention is shown in Fig. 2 from Levi Setti (1969).

E. 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 $\mu^\pm\rightarrow e^\pm+\nu+\bar{\nu}$. Assuming a local and lepton-conserving interaction, the matrix element may be written as

$$\sum_i \langle \bar{e}\mid \Gamma_i \mid \mu\rangle\langle\bar{\nu}\mid \Gamma_i(C_i+C_i'\gamma_5)\mid\nu\rangle, \tag{14}$$

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:

$$\rho = [3g_A^2 + 3g_V^2 + 6g_T^2]/D, \tag{15}$$

$$\eta = [g_S^2 - g_P^2 + 2g_A^2 - 2g_V^2]/D, \tag{16}$$

for the asymmetry parameters:

$$\xi = [+6g_S g_P \cos\phi_{SP} - 8g_A g_V \cos\phi_{AV} + 14g_T^2 \cos\phi_{TT}]/D, \tag{17}$$

$$\delta = [-6g_A g_V \cos\phi_{AV} + 6g_T^2 \cos\phi_{TT}]/D\xi, \tag{18}$$

and for the parameter describing the helicity of the electron:

$$h = \pm[2g_S g_P \cos\phi_{SP} - 8g_A g_V \cos\phi_{AV} - 6g_T^2 \cos\phi_{TT}]/D. \tag{19}$$

Here

$$D = g_S^2 + g_P^2 + 4g_V^2 + 6g_T^2 + 4g_A^2, \tag{20}$$

$$g_i^2 = |C_i|^2 + |C_i'|^2, \tag{21}$$

and

$$\cos\phi_{ij} = \mathrm{Re}\,(C_i^* C_j' + C_i' C_j^*). \tag{22}$$

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 ϕ_{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 ϕ_{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 $\sin\phi_{AV}$ 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 ϕ_{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 ϕ_{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.

F. *K*-Decay Parameters

F.1. Dalitz Plot for $K \to 3\pi$ Decays

The small deviation from uniformity of the Dalitz plot for the 3π decay of the K meson is usually described by a "slope parameter" (Dalitz, 1956). For the τ and τ' decays of the charged K's, and the τ^0 decay mode of the K_L^0, we parametrize the Dalitz plot distribution by the expression

$$|M|^2 \propto 1 + g[(s_3 - s_0)/m_{\pi^+}^2] + h[(s_3 - s_0)/m_{\pi^+}^2]^2 + j[(s_2 - s_1)/m_{\pi^+}^2] + \cdots, \tag{23}$$

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

$$s_i = (P_K - P_i)^2 = (m_K - m_i)^2 - 2m_K T_i \qquad i = 1, 2, 3 \tag{24}$$

$$s_0 = \tfrac{1}{3} \sum_i s_i = \tfrac{1}{3}(m_K^2 + m_1^2 + m_2^2 + m_3^2). \tag{25}$$

Here the P_i are 4-vectors, m_i and T_i are 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 measures the quadratic dependence on s_3. The coefficient j is related to the asymmetry of the plot and must be zero if CP invariance holds. Note also that if CP is good, g must be the same for τ^+ and τ^-, and similarly for h.

At present there is no compelling experimental evidence for either the h or the j term (for upper limits on the j term, see section F.3(b) below). Thus we stop the above expansion at the first term and list only g. Since different experiments use different forms for $|M|^2$, in order to compare the experiments we have converted to g 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.

F.2. Form Factors in K_{l3} Leptonic Decays

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

$$M \propto f_+(q^2)[(P_K + P_\pi)_\mu \bar{u}_l \gamma_\mu (1+\gamma_5) u_\nu] + f_-(q^2)[m_l \bar{u}_l (1+\gamma_5) u_\nu], \tag{26}$$

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 $q^2 = (P_K - P_\pi)^2$, the square of the momentum transfer to the leptons. The parameters we list are $\lambda_\pm$, the energy dependence of the $f_\pm(q^2)$ form factor, assuming the form

$$f_\pm(q^2) = f_\pm(0)[1 + \lambda_\pm (q/m_\pi)^2]; \tag{27}$$

and ξ, the ratio of the two form factors,

$$\xi = f_- / f_+ . \tag{28}$$

The quantity ξ can be determined in different ways:

(1) By measuring the $K_{\mu 3}/K_{e3}$ branching ratio and comparing it with the theoretical ratio as given in terms of $\xi(0) = f_-(0)/f_+(0)$.

$$\begin{aligned} \Gamma(K_{\mu 3}{}^{\pm})/\Gamma(K_{e3}{}^{\pm}) &= 0.6457 + 0.1264 \operatorname{Re} \xi + 0.0192 \,|\, \xi \,|^2 \\ &\quad + 1.4115\lambda_+ + 0.4754\lambda_- \operatorname{Re} \xi + 0.0080\lambda_+ \operatorname{Re} \xi, \\ \Gamma(K_{\mu 3}{}^0)/\Gamma(K_{e3}{}^0) &= 0.6452 + 0.1246 \operatorname{Re} \xi + 0.0186 \,|\, \xi \,|^2 \\ &\quad + 1.3162\lambda_+ + 0.4370\lambda_- \operatorname{Re} \xi + 0.0064\lambda_+ \operatorname{Re} \xi. \end{aligned} \tag{29}$$

See Cabibbo (1966) and Fearing *et al.* (1970) (for the charge-dependent formulas). Note that the first constant has been changed to 0.6457; the earlier value was a misprint,[2] which we copied from Cabibbo (1966).

(2) By studying the Dalitz plot of the $K_{\mu 3}$ decay. The K_{e3} Dalitz plot distribution is only dependent upon the λ_+ parameter, whereas the $K_{\mu 3}$ distribution is dependent upon λ_-, λ_+, ξ. Often experimenters have measured only the momentum spectrum of either the π or the lepton and compared it with the predicted spectrum. See the note on form factors in the $K^\pm$ Data Card Listings for a discussion of this method. For a formula relating the Dalitz plot variables to ξ see, for example, Brene *et al.* (1961).

(3) 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

$$\begin{aligned} \mathbf{A} = \alpha_1(\xi)\mathbf{p}_\mu - \alpha_2(\xi)\{(\mathbf{p}_\mu/m_\mu)[m_K - E_\pi \\ + (\mathbf{p}_\pi \cdot \mathbf{p}_\mu / |\,\mathbf{p}_\mu\,|^2)(E_\mu - m_\mu)] + \mathbf{p}_\pi\} \\ + m_K \operatorname{Im} \xi(q^2)(\mathbf{p}_\pi \times \mathbf{p}_\mu). \end{aligned} \tag{30}$$

If time-reversal invariance holds, ξ is real, and thus there is no polarization perpendicular to the K-decay plane.

If we remove the assumption of a pure vector current, then the matrix element for the decay, in addition to the terms in Eq. (26), would contain

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

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 experimental results for ξ, $\lambda_\pm$, and the upper limits on $|\,f_S/f_+\,|$ and $|\,f_T/f_+\,|$ are given in the $K^\pm$ and $K_L{}^0$ sections of the Stable Particle Data Card Listings. See the note on form factors in the $K^\pm$ Data Card Listings for discussions of these results.

F.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

$$A_S(K_S \to \pi^+\pi^-\pi^0)/A_L(K_L \to \pi^+\pi^-\pi^0) \equiv x + iy. \tag{31}$$

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 (31) 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 (23) describing the Dalitz plot distribution for $\tau^\pm$, τ^0 decays of K mesons would be an indication of CP violation. Rather than listing values of the $(s_2 - s_1)$ coefficient j in Eq. (23), we choose to list $\sigma_\pm$ from the equivalent expression

$$\begin{aligned} |\,M\,|^2 \propto 1 + \sigma_\pm (2/\sqrt{3})(T_+ - T)/T_{\pm\max} \\ + (CP \text{ nonviolating terms}), \end{aligned} \tag{32}$$

where $T_\pm$ are the kinetic energies of the charged pions. We have momentarily abandoned the form involving the Mandelstam variables s_i in favor of (32) because the latter has been consistently used by experimenters searching for CP violation. We list $\sigma_\pm$ 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

$$\delta = \frac{\Gamma(K_L \to \pi^- l^+ \nu) - \Gamma(K_L \to \pi^+ l^- \nu)}{\Gamma(K_L \to \pi^- l^+ \nu) + \Gamma(K_L \to \pi^+ l^- \nu)} . \tag{33}$$

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

$$\delta = 2[(1 - |\,x\,|^2)/(|\,1 - x\,|^2)] \operatorname{Re} \epsilon, \tag{34}$$

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

$$|\,K_L\rangle = [(1+\epsilon)\,|\,K\rangle - (1-\epsilon)\,|\,\bar{K}\rangle]/[2(1+|\,\epsilon\,|^2)]^{1/2}, \tag{35a}$$

$$|\,K_S\rangle = [(1+\epsilon)\,|\,K\rangle + (1-\epsilon)\,|\,\bar{K}\rangle]/[2(1+|\,\epsilon\,|^2)]^{1/2}. \tag{35b}$$

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[2] We thank Drs. H. W. Fearing and J. Smith for calling this mistake to our attention.

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 $K_L^0 \rightarrow \pi\mu\nu$ and $K_L^0 \rightarrow \pi e\nu$.

(d) $K_L \rightarrow 2\pi$ *decay*. The relevant parameters are

$$\eta_{+-} = A(K_L \rightarrow \pi^+\pi^-)/A(K_S \rightarrow \pi^+\pi^-) = |\eta_{+-}| \exp(i\phi_{+-}), \tag{36}$$

$$\eta_{00} = A(K_L \rightarrow \pi^0\pi^0)/A(K_S \rightarrow \pi^0\pi^0) = |\eta_{00}| \exp(i\phi_{00}), \tag{37}$$

ϵ, defined in Eqs. (35) above, and

$$\epsilon' = \tfrac{1}{2} i\sqrt{2}[\exp i(\delta_2 - \delta_0)] \operatorname{Im}(A_2/A_0). \tag{38}$$

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

$$\langle I=0 \mid T \mid K \rangle = \exp(i\delta_0) A_0, \tag{39a}$$

$$\langle I=2 \mid T \mid K \rangle = \exp(i\delta_2) A_2. \tag{39b}$$

Wu and Yang (1964) have derived the relationships

$$\eta_{+-} = \epsilon + \epsilon', \tag{40a}$$

$$\eta_{00} = \epsilon - 2\epsilon'. \tag{40b}$$

At present many models have been proposed to explain the experimental results on CP violation, but more data are needed before the cause of CP violation can be ascertained.

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.

F.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

$$x = A(\bar{K}^0 \rightarrow \pi^- l^+ \nu)/A(K^0 \rightarrow \pi^- l^+ \nu). \tag{41}$$

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.

G. η-Decay Parameters

As a test of possible C violation in electromagnetic interactions, a number of experiments have looked for possible charge asymmetries in the decays $\eta \rightarrow \pi^+\pi^-\pi^0$ and $\eta \rightarrow \pi^+\pi^-\gamma$. For both modes we use the convention

$$\text{Asymmetry} = f(+) - f(-),$$

where $f(\pm)$ means the fraction of the events with the $\pi^{(\pm)}$ energy greater than the $\pi^{(\mp)}$ energy in the η rest frame. We list the asymmetry parameters in the η section of the Stable Particle Data Card Listings and give average values in the Addendum to the Stable Particle Table.

H. Baryon-Decay Parameters

H.1. A/V Ratio for Baryon Leptonic Decays

Consider the decay

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

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

$$\langle B_f \mid \gamma_\lambda (g_V - g_A \gamma_5) + (g_W/m_{B_i}) \sigma^{\lambda\nu} q_\nu \mid B_i \rangle, \tag{42}$$

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 definition of g_A/g_V is

$$g_A/g_V = |g_A/g_V| \exp(i\delta), \tag{43}$$

where δ is $0 + n\pi$ if time-reversal invariance holds (see Jackson *et al.*, 1957).

In neutron beta decay the measurements are consistent with time reversal, so g_A/g_V is nearly real and has been considered to be such in all the baryon leptonic decays. Notice that 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).

We compile the ratio g_A/g_V with its sign, for those decays for which it has been measured. For the neutron beta decay we compile also the phase δ.

All the coupling constants and decay rates for baryon leptonic decays are related by Cabibbo's theory (Cabibbo, 1964). The latest fit to this theory can be found in Ebenhöh (1971).

H.2. Asymmetry Parameters in Nonleptonic Hyperon Decays.

The transition matrix for the hyperon decay may be written as

$$M = s + p(\boldsymbol{\sigma}\cdot\mathbf{q}), \tag{44}$$

where s and p are the parity-changing and the parity conserving amplitudes, respectively, $\boldsymbol{\sigma}$ 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

$$\alpha = 2\,\mathrm{Re}\,(s^*p)/(|s|^2+|p|^2), \tag{45a}$$

$$\beta = 2\,\mathrm{Im}\,(s^*p)/(|s|^2+|p|^2), \tag{45b}$$

$$\gamma = (|s|^2-|p|^2)/(|s|^2+|p|^2). \tag{45c}$$

With the transition matrix (44), the angular distribution of the decay baryon, in the hyperon rest system, is of the form

$$I = 1 + \alpha \mathbf{P}_Y\cdot\mathbf{q}, \tag{46}$$

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

In the notation of Lee and Yang (1957) the polarization $\mathbf{P}_B$ of the decay baryon is[3]

$$\mathbf{P}_B = \frac{(\alpha+\mathbf{P}_Y\cdot\mathbf{q})\mathbf{q}+\beta(\mathbf{P}_Y\times\mathbf{q})+\gamma\mathbf{q}\times(\mathbf{P}_Y\times\mathbf{q})}{1+\alpha\mathbf{P}_Y\cdot\mathbf{q}}, \tag{47}$$

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

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

$$\alpha^2+\beta^2+\gamma^2 = 1. \tag{48}$$

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

$$\beta = (1-\alpha^2)^{1/2}\sin\phi, \tag{49a}$$

$$\gamma = (1-\alpha^2)^{1/2}\cos\phi, \tag{49b}$$

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

$$-\tfrac{1}{2}\pi \leq \phi \leq \tfrac{1}{2}\pi \quad \text{for} \quad \gamma > 0, \tag{50a}$$

$$+\tfrac{1}{2}\pi \leq \phi \leq \tfrac{3}{2}\pi \quad \text{for} \quad \gamma < 0. \tag{50b}$$

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

$$\alpha = 2\,|s|\,|p|\cos\Delta/(|s|^2+|p|^2), \tag{51a}$$

$$\beta = -2\,|s|\,|p|\sin\Delta/(|s|^2+|p|^2); \tag{51b}$$

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

$$-\tfrac{1}{2}\pi \leq \Delta \leq \tfrac{1}{2}\pi \quad \text{for} \quad \alpha > 0, \tag{52a}$$

$$+\tfrac{1}{2}\pi \leq \Delta \leq \tfrac{3}{2}\pi \quad \text{for} \quad \alpha < 0. \tag{52b}$$

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

$$\Delta = \delta_s - \delta_p, \tag{53}$$

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,

$$\Delta = \delta_s - \delta_p = (6.8\pm2.0)\ \text{deg.}^{[4]}$$

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.

V. STATISTICAL PROCEDURES

This section is a much abbreviated version of Section IX in the text of our January 1970 edition (Particle Data Group, 1970) to which the reader is referred for details. See also the mini-review on K^* masses and mass differences in the $K^*(892)$ section of the Meson Data Card Listings.

A. Confidence Levels and Errors

Quoted errors represent one standard deviation (σ). Upper and lower limits represent 68.3% confidence

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[3] 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.

[4] This value for $\delta_s - \delta_p$ is derived from the phase-shift analyses by Roper *et al.* (1965). The error is our estimation of the uncertainty.

bounds (1σ), unless otherwise stated. The errors in the Tables of Particle Properties and the errors of the averages in the Data Card Listings often include a scale factor S; see section V.B. below.

Quantities that have changed more than 1σ since our April 1972 edition (Particle Data Group, 1972) are italicized in the Tables of Particle Properties. For a discussion see Section V.B in the text of the 1970 edition (Particle Data Group, 1970).

B. Unconstrained Averaging Scale Factors

In the absence of constraints, we calculate a weighted average

$$\bar{x}\pm\delta\bar{x}=\sum w_i x_i/\sum w_i \pm \left(\sum w_i\right)^{-1/2};$$

$$w_i=1/(\delta x_i)^2, \tag{54}$$

where the sums run over N experiments. We also calculate χ^2 and compare it with its expectation value of $N-1$. If $\chi^2>N-1$, we increase the error $\delta\bar{x}$ in Eq. (54) by a factor

$$S=[\chi^2/(N-1)]^{1/2}. \tag{55}$$

It is easy to design statistical tests for determining whether one experiment (or a group of experiments) is consistent with the other experiments. However, statistics does not tell us who is wrong in case of contradictions. When $S\gg1$, one can conclude either that:

(1) some (or all) experiments are wrong, or

(2) some (or all) experiments have underestimated their errors, or

(3) the experiments do not measure the same quantity (systematic errors).

We do our best to resolve these cases. If we cannot, we *assume* that *all* experimentalists underestimated their errors by the same scale factor. 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 procedure is straightforward. If, however, there are both precise and imprecise (large errors) measurements of a particular quantity, one must be very careful not to permit the imprecise ones to "dilute" the scale factor. See our January 1970 edition (Particle Data Group, 1970) for the prescription we use to handle this effect.

We often plot an ideogram to guide the reader in deciding which data he might reject before making his own selected average.

For further discussion of ideograms and scale factors, we refer the reader to Section IX of our January 1970 edition (Particle Data Group, 1970).

C. Constrained Fits

The information on partial-decay fractions P_i[5] and partial widths $\Gamma_i=P_i\Gamma_{\text{total}}$ is frequently given by branching ratios R_j, say, $R_1=P_1/(P_1+P_2)$, $R_2=P_2/P_3$, $R_3=P_1/P_2$, $R_4=P_3/(P_1+P_2+P_3)$, etc.[6]

The number of experimental inputs R_j is often greater than the number of decay modes. In these cases we fit all available information on the P_i, Γ_i, and R_j subject to the constraint $\sum P_i=1$. When, in addition, the input R_j are contradictory so that scale factors may have to be introduced, one has to resort to iterative procedures.

The Data Card Listings give the values of the fitted R_i, P_i, and Γ_i, together with the error matrices of the P_i and of the Γ_i. For details about this procedure, the reader is referred to the text of the January 1970 edition (Particle Data Group, 1970), Sec. IV.B.

VI. PARTICLE DATA GROUP PUBLICATIONS

To obtain a reprint of this report, or any of the items listed below, write either Scientific Information Service, CERN, or Technical Information Division, Lawrence Berkeley Laboratory, whichever is closer.

A. Pocket-Sized Particle Data Booklet

In addition to the present complete, full-size version of the Review of Particle Properties available from CERN and LBL, a pocket-size data booklet is available. It contains the first part of this report, up to the Data Card Listings. The complete set of pocket-size items available comprises the data booklet, a 16-month diary, a mini-atlas contributed by Digital Equipment Corporation, and a plastic cover. Any of these items that you have requested in the past will automatically be sent to you, but please note that our mailing lists are self-cancelling; unless you return the request card that is sent once a year, your name will be removed from our mailing list. If you wish to order any items in bulk we must charge 25 cents (US) for each of the pocket-sized items.

B. Other Compilations

We compile data not only on particle properties, but also on other aspects of strong interactions (πN, KN, pN, $\cdots$ cross sections; partial-wave amplitudes, etc.) Until 1971, our reports were called UCRL 20 000; they are now numbered LBL 50, $\cdots$, 99. In the front of each of these reports is a list of all relevant compilations. A complementary series of compilations is

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[5] We use the symbol P_i for partial-decay fractions throughout the Data Card Listings for stable particles, mesons, and baryons, although for baryons x_i is the commonly accepted symbol. See Eq. (10).

[6] We are also able to fit *products* of rates from formation experiments as given in Eq. (12).

produced by the CERN HERA Group. Both series are available from both LBL and CERN.

C. Magnetic Tapes

The Particle Data Group at LBL also has available for distribution magnetic tapes containing cross section data compilations produced by E. Flaminio *et al.* (πN, KN, $\bar{K}N$, NN, $\bar{N}N$); G. Giacomelli *et al.* (πN); C. Lovelace *et al.* (πN; some KN, $\bar{K}N$); L. D. Roper *et al.* ($\bar{K}N$); P. Spillantini and V. Valente, or H. Oberlack (γN); and F. Wagner *et al.* (KN, $\bar{K}N$; some πN). The original versions of these tapes are available immediately, while updated and corrected versions will be available in the near future. In addition, tapes containing partial-wave amplitudes for πN, KN, and γN exist and may also be requested. If you are interested in more details on the contents of any of these tapes, please write us.

D. Next Edition

We currently produce a new Review of Particle Properties every April. It is published alternately by Physics Letters and by Reviews of Modern Physics.

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REFERENCES

Albright, C. H., Phys. Rev. **115**, 750 (1959).
Ascoli, Giulio, papers submitted to the "Third Philadelphia Conference", American Institute of Physics, New York, 1972; and to the XVI International Conference on High Energy Physics, NAL, 1972.
Barbaro-Galtieri, A., Baryon resonances, in: *Advances in Particle Physics*, edited by R. L. Cool and R. E. Marshak (Wiley, New York, 1968), Vol. 2. See specifically, Table IV and Figs. 10 and 12.
Bender, I., V. Linke, and H. J. Rothe, Z. Physik **212**, 190 (1968).
Brene, N., L. Egardt, and B. Qvist, Nucl. Phys. **22**, 553 (1961).
Cabibbo, N., Phys. Rev. Lett. **10**, 531 (1963).
——, and A. Maksymowicz, Phys. Letters **9**, 352 (1964).
——, Proc. 13th Intern. Conf. on High-Energy Physics, Berkeley, 1966 (University of California Press, Berkeley, 1967), p. 34.
Chew, G. F., in *Estratto da Old and New Problems in Elementary Particles*, edited by G. Puppi (Academic, New York, 1968).
Dalitz, R. H., Proc. Phys. Soc. (London) **69A**, 527 (1956).
Ebenhöh, H., F. Eisele, H. Filthuth, W. Föhlisch, V. Hepp, E. Leitner, W. Presser, H. Schneider, T. Thouw, and G. Zech, Z. Physik **241**, 473 (1971).
Fearing, H. W., E. Fischbach and J. Smith, Phys. Rev. **D2**, 542 (1970).
Gasiorowicz, S., *Elementary Particle Physics* (Wiley, New York, 1966).
Goldberger, M. L., and S. B. Treiman, Phys. Rev. **111**, 354 (1958).
Herndon, D. J., A. Barbaro-Galtieri, and A. H. Rosenfeld, "πN partial-wave amplitudes—A Compilation," Lawrence Radiation Laboratory Report UCRL-20030 πN, Feb. 1972, p. 4, Eq. (9).
Jackson, J. D., S. B. Treiman and H. W. Wyld Jr., Phys. Rev. **106**, 517 (1957).
Jackson, J. D., Nuovo Cimento **34**, 1644 (1964).
Källén, G., *Elementary Particle Physics* (Addison-Wesley Publ. Co., Reading, Mass., 1964).
Kinoshita, T., and A. Sirlin, Phys. Rev. **108**, 844 (1957).
Lee, T. D., and C. N. Yang, Phys. Rev. **108**, 1645 (1957).
Levi Setti, R., Rapporteur talk at the Lund Intern. Conf. on Particle Physics (Lund, June 1969).
Okun, L. B., and C. Rubbia, Proc. Heidelberg Conf. on Elementary Particles (1967), p. 301.
Particle Data Group (1969): N. Barash-Schmidt, A. Barbaro-Galtieri, L. R. Price, A. H. Rosenfeld, P. Söding, C. G. Wohl, M. Roos and G. Conforto, Rev. Mod. Phys. **41**, 109 (1969).
Particle Data Group (1970): A. Barbaro-Galtieri, S. E. Derenzo, L. R. Price, A. Rittenberg, A. H. Rosenfeld, N. Barash-Schmidt, C. Bricman, M. Roos, P. Söding and C. G. Wohl, Rev. Mod. Phys. **42**, 87 (1970).
Particle Data Group (1972): P. Söding, J. Bartels, A. Barbaro-Galtieri, J. E. Enstrom, T. A. Lasinski, A. Rittenberg, A. H. Rosenfeld, T. G. Trippe, N. Barash-Schmidt, C. Bricman, V. Chaloupka and M. Roos, Phys. Letters **39B**, No. 1 (1972).
Pišut, J., and M. Roos, Nucl. Phys. **B6**, 325 (1968).
Roper, L. D., R. M. Wright, and B. T. Feld, Phys. Rev. **138**, B190 (1965).
Steinberger, J., CERN Topical Conference on Weak Interactions, CERN 69-7 (1969), p. 291.
Willis, W., and J. Thompson, Leptonic Decays of Elementary Particles, in *Advances in Particle Physics*, edited by R. L. Cool and R. E. Marshak (Wiley, New York, 1968), Vol. 1, p. 295.
Wolfenstein, L. in: *Theory and Phenomenology in Particle Physics*, edited by A. Zichichi (Academic, New York, 1969), p. 218.
Wright, Jon, Illinois preprint, submitted to XVI International Conference on High Energy Physics, NAL, 1972.
Wu, T. T., and C. N. Yang, Phys. Rev. Letters **12**, 380 (1964).

TABLES OF PARTICLE PROPERTIES

April 1973

N. Barash-Schmidt, A. Barbaro-Galtieri, C. Bricman, V. Chaloupka
R. L. Kelly, T. A. Lasinski, A. Rittenberg, M. Roos, A. H. Rosenfeld,
P. Söding, and T. G. Trippe

(Closing date for data: Feb. 1, 1973)

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 1972.

Particle	$I^G(J^P)C_n$	Mass (MeV) Mass^2 (GeV)^2	Mean life (sec) $c\tau$ (cm)	Partial decay mode		
				Mode	Fraction^a	p or p_{max}^{b} (MeV/c)
γ	$0,1(1^-)^-$	$0(<2)10^{-21}$	stable	stable		
ν ν_e	$J=\frac{1}{2}$	0(< 60 eV)	stable	stable		
ν_μ		0(< 1.2)				
e	$J=\frac{1}{2}$	0.5110041	stable	stable		
		±.0000016	($>2\times10^{21}$y)			
μ	$J=\frac{1}{2}$	105.6595	2.1994×10^{-6}	$e\nu\bar{\nu}$	100	53
		±.0003	±.0006 S=1.1*	$e\gamma\gamma$	$(<1.6)10^{-5}$	53
		$m^2=0.0112$	$c\tau=6.593\times10^4$	3e	$(<6)10^{-9}$	53
	$m_\mu-m_{\pi^\pm}=$	−33.909		$e\gamma$	$(<2.2)10^{-8}$	53
		±.006				
$\pi^\pm$	$1^-(0^-)$	139.5688	2.6024×10^{-8}	$\mu\nu$	100 %	30
		±.0064	±.0024	$e\nu$	$(1.24\pm0.03)10^{-4}$	70
		$m^2=0.0195$	$c\tau=780.2$	$\mu\nu\gamma$	$^c(1.24\pm0.25)10^{-4}$	30
			$(\tau^+-\tau^-)/\bar{\tau}=$	$\pi^0e\nu$	$(1.02\pm0.07)10^{-8}$	5
			$(0.05\pm0.07)\%$	$e\nu\gamma$	$^c(3.0\pm0.5)10^{-8}$	70
			(test of CPT)	$e\nu e^+e^-$	$(<3.4)10^{-8}$	70
π^0	$1^-(0^-)^+$	134.9645	0.84×10^{-16}	$\gamma\gamma$	$(98.83\pm0.05)\%$	67
		±.0074	±.10 S=2.1*	γe^+e^-	$(1.17\pm0.05)\%$	67
		$m^2=0.0182$	$c\tau=2.5\times10^{-6}$	$\gamma\gamma\gamma$	$(<5)10^{-6}$	67
	$m_{\pi^\pm}-m_{\pi^0}=$	4.6043		$e^+e^-e^+e^-$	$^d(3.47)10^{-5}$	67
		±.0037				

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)C_n$	Mass (MeV) Mass^2 (GeV)^2	Mean life (sec) $c\tau$ (cm)	Partial decay mode		
				Mode	Fraction[a]	p or p_{max}[b] (MeV/c)
$K^{\pm}$	$\frac{1}{2}(0^-)$	*493.715*	1.2371×10^{-8}	$\mu\nu$	$(63.52\pm0.19)\%$	236
		±0.037	±.0026 S=1.9*	$\pi\pi^0$	$(21.06\pm0.18)\%$ S=1.1*	205
			$c\tau=370.8$	$\pi\pi^-\pi^+$	$(5.59\pm0.03)\%$ S=1.1*	125
		$m^2=0.244$	$(\tau^+-\tau^-)/\bar{\tau}=$	$\pi\pi^0\pi^0$	$(1.73\pm0.05)\%$ S=1.4*	133
			(.11±.09)%	$\mu\pi^0\nu$	$(3.24\pm0.10)\%$ S=1.9*	215
			(test of CPT)	$e\pi^0\nu$	$(4.85\pm0.06)\%$ S=1.1*	228
			S=1.2*	$e\pi^0\pi^0\nu$	$(1.8^{+2.4}_{-0.6})\,10^{-5}$	207
		$m_{K^\pm}-m_{K^0}=-3.99$		$\pi\pi^\mp e^\pm\nu$	$(3.7\pm0.2)\,10^{-5}$	203
		±0.13		$\pi\pi^\pm e^\mp\nu$	$(<5)\,10^{-7}$	203
		S=1.1*		$\pi\pi^\mp\mu^\pm\nu$	$(0.9\pm0.4)\,10^{-5}$	151
				$\pi\pi^\pm\mu^\mp\nu$	$(<3)\,10^{-6}$	151
				$e\nu$	$(1.38\pm0.20)\,10^{-5}$	247
				$e\nu\gamma$	c $(<7)\,10^{-5}$	247
				$\pi\pi^0\gamma$	h, c $(2.66\pm0.18)\,10^{-4}$	205
				$\pi\pi^+\pi^-\gamma$	c $(10\pm4)\,10^{-5}$	125
				$\pi e\nu\gamma$	c $(3.7\pm1.4)\,10^{-4}$	227
				πe^+e^-	$(<0.4)\,10^{-6}$	227
				$\pi^\mp e^\pm e^\pm$	$(<1.5)\,10^{-5}$	227
				$\pi\mu^+\mu^-$	$(<2.4)\,10^{-6}$	172
				$\pi\gamma\gamma$	c $(<3.5)\,10^{-5}$	227
				$\pi\gamma\gamma\gamma$	c $(<3)\,10^{-4}$	227
				$\pi\nu\bar{\nu}$	$(<1.4)\,10^{-6}$	227
				$\pi\gamma$	$(<4)\,10^{-6}$	227
				$\pi^\mp e^\pm\mu^\pm$	$(<3)\,10^{-8}$	214
				$\pi^\pm e^\pm\mu^\mp$	$(<1.4)\,10^{-8}$	214
				$\mu\nu\nu\bar{\nu}$	$(<7)\,10^{-6}$	236
K^0	$\frac{1}{2}(0^-)$	497.71 ±0.13	50% K_{Short}, 50% K_{Long}			
K^0_S	$\frac{1}{2}(0^-)$	S=1.1*	^{e}*0.882×10⁻¹⁰*	$\pi^+\pi^-$	$(68.81\pm0.29)\%$ S=1.1*	206
		$m^2=0.248$	*±.008* S=2.5 *	$\pi^0\pi^0$	$(31.19)\%$	209
			$c\tau=2.65$	$\mu^+\mu^-$	$(<0.7)\,10^{-5}$	225
				e^+e^-	$(<35)\,10^{-5}$	249
				$\pi^+\pi^-\gamma$	c $(2.3\pm0.8)\,10^{-3}$	206
				$\gamma\gamma$	$(<0.7)\,10^{-3}$	249
K^0_L	$\frac{1}{2}(0^-)$		5.181×10^{-8}	$\pi^0\pi^0\pi^0$	$(21.5\pm0.8)\%$ S=1.4*	139
			±0.041	$\pi^+\pi^-\pi^0$	$(12.6\pm0.3)\%$	133
			$c\tau=1553$	$\pi\mu\nu$	$(26.9\pm0.6)\%$ S=1.1*	216
				$\pi e\nu$	$(38.8\pm0.6)\%$ S=1.1*	229
				$\pi e\nu\gamma$	c $(1.3\pm0.8)\%$	229
		$m_{K_L}-m_{K_S}=0.5402\times10^{10}\,\hbar\,\mathrm{sec}^{-1}$		$\pi^+\pi^-$	$(0.157\pm0.005)\%$	206
		± 0.0035		$\pi^0\pi^0$	$(0.094\pm0.019)\%$ S=1.5*	209
				$\pi^+\pi^-\gamma$	c $(<0.4)\,10^{-3}$	206
				$\pi^0\gamma\gamma$	$(<2.4)\,10^{-4}$	231
				$\gamma\gamma$	$(4.9\pm0.4)\,10^{-4}$	249
				$e\mu$	i $(<1.6)\,10^{-9}$	238
				$\mu^+\mu^-$	$(<1.9)\,10^{-9}$	225
				e^+e^-	$(<1.6)\,10^{-9}$	249
η	$0^+(0^-)^+$	548.8	$^{e}\Gamma=(2.63\pm0.58)$keV	$\gamma\gamma$	$(38.0\pm1.0)\%$ S=1.2*	274
		±0.6	Neutral decays	$\pi^0\gamma\gamma$	e $(3.1\pm1.1)\%$ S=1.2*	258
		S=1.4*	71.1%	$3\pi^0$	$(30.0\pm1.1)\%$ S=1.1*	180
		$m^2=0.301$		$\pi^+\pi^-\pi^0$	$(23.9\pm0.6)\%$ S=1.1*	175
				$\pi^+\pi^-\gamma$	$(5.0\pm0.1)\%$	236
			Charged decays	$\pi^0e^+e^-$	$(<0.04)\%$	258
			28.9%	$\pi^+\pi^-e^+e^-$	$(0.1\pm0.1)\%$	236
				$\pi^+\pi^-\pi^0\gamma$	$(<0.2)\%$	175
				$\pi^+\pi^-\gamma\gamma$	$(<0.2)\%$	236
				$\mu^+\mu^-$	$(2.2\pm0.8)\,10^{-5}$	253
				$\mu^+\mu^-\pi^0$	$(<5)\,10^{-4}$	211
p	$\frac{1}{2}(\frac{1}{2}^+)$	938.2592	stable			
		±0.0052	$(>2\times10^{28}y)$			
		$m^2=0.8803$				
n	$\frac{1}{2}(\frac{1}{2}^+)$	939.5527	*(0.918±0.014)10³*	$pe^-\nu$	100 %	1
		±0.0052	$c\tau=2.75\times10^{13}$			
		$m^2=0.8828$				
		$m_p-m_n=-1.29344$				
		±0.00007				

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)C_n$	Mass (MeV) Mass^2 (GeV)^2	Mean life (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction^a	p or p_{max}^{b} (MeV/c)
Λ	$0(\frac{1}{2}^+)$	1115.59	2.521×10^{-10}	$p\pi^-$	$(64.2\ \pm0.5\ )\%$	100
		±0.05	$\pm.021$ S=1.2*	$n\pi^0$	$(35.8\ )\%$	104
		S=1.1*	$c\tau$ = 7.56	$pe\nu$	$(8.13\pm0.29)10^{-4}$	163
		m^2= 1.245		$p\mu\nu$	$(1.57\pm0.35)10^{-4}$	131
				$p\pi^-\gamma$	c$(0.85\pm0.14)10^{-3}$	100
Σ^+	$1(\frac{1}{2}^+)$	1189.41	0.800×10^{-10}	$p\pi^0$	$(51.6\ \pm0.7\ )\%$	189
		±0.07	$\pm.006$	$n\pi^+$	$(48.4\ )\%$	185
		S= 1.6*	$c\tau$ = 2.40	$p\gamma$	c$(1.24\pm0.18)10^{-3}$ S=1.4*	225
		m^2= 1.415		$n\pi^+\gamma$	$(1.31\pm0.24)10^{-4}$	185
		$m_{\Sigma^+}-m_{\Sigma^-}$= -7.94		$\Lambda e^+\nu$	$(2.02\pm0.47)10^{-5}$	72
		$\pm.09$	$\frac{\Gamma(\Sigma^+\to\ell^+n\nu)}{\Gamma(\Sigma^-\to\ell^-n\nu)}<.035\leftarrow$	$n\mu^+\nu$	$(<2.4\ )10^{-5}$	202
		S= 1.2		$ne^+\nu$	$(<1.0\ )10^{-5}$	224
				pe^+e^-	$(<7\ )10^{-6}$	225
Σ^0	$1(\frac{1}{2}^+)$	1192.48	$<1.0\times10^{-14}$	$\Lambda\gamma$	100 %	74
		±0.10	$c\tau<3\times10^{-4}$	Λe^+e^-	d$(5.45\ )10^{-3}$	74
		S= 1.1*				
		m^2=1.422				
Σ^-	$1(\frac{1}{2}^+)$	1197.34	1.484×10^{-10}	$n\pi^-$	100 %	193
		±0.07	$\pm.019$ S=1.6*	$ne^-\nu$	$(1.10\pm0.05)10^{-3}$	230
		S= 1.2*	$c\tau$ = 4.45	$n\mu^-\nu$	$(0.45\pm0.04)10^{-3}$	210
		m^2 = 1.434		$\Lambda e^-\nu$	$(0.60\pm0.06)10^{-4}$	79
		$m_{\Sigma^0}-m_{\Sigma^-}$=-4.86		$n\pi^-\gamma$	c$(1.0\ \pm0.2\ )10^{-4}$	193
		$\pm.06$				
Ξ^0	$\frac{1}{2}(\frac{1}{2}^+)^f$	1314.9	2.98×10^{-10}	$\Lambda\pi^0$	100 %	135
		±0.6	$\pm.12$	$p\pi^-$	$(<0.9\ )10^{-3}$	299
		m^2= 1.729	$c\tau$ = 8.93	$pe^-\nu$	$(<1.3\ )10^{-3}$	323
		$m_{\Xi^0}-m_{\Xi^-}$ =-6.4		$\Sigma^+e^-\nu$	$(<1.5\ )10^{-3}$	119
		$\pm.6$		$\Sigma^-e^+\nu$	$(<1.5\ )10^{-3}$	112
				$\Sigma^+\mu^-\nu$	$(<1.5\ )10^{-3}$	64
				$\Sigma^-\mu^+\nu$	$(<1.5\ )10^{-3}$	49
				$p\mu^-\nu$	$(<1.3\ )10^{-3}$	309
Ξ^-	$\frac{1}{2}(\frac{1}{2}^+)^f$	1321.29	1.672×10^{-10}	$\Lambda\pi^-$	100 %	139
		±0.14	$\pm.032$ S=1.1*	$\Lambda e^-\nu$	g$(0.70\pm0.21\ )10^{-3}$	190
		m^2= 1.746	$c\tau$ = 5.01	$\Sigma^0e^-\nu$	$(<0.5\ )10^{-3}$	123
				$\Lambda\mu^-\nu$	$(<1.3\ )10^{-3}$	163
				$\Sigma^0\mu^-\nu$	$(<0.5\ )\%$	70
				$n\pi^-$	$(<1.1\ )10^{-3}$	303
				$ne^-\nu$	$(<1.0\ )\%$	327
Ω^-	$0(\frac{3}{2}^+)^f$	1672.5$\pm$.5	$1.3^{+0.4}_{-0.3}\times10^{-10}$	$\Xi^0\pi^-$	Total of	294
		m^2= 2.797	$c\tau$ = 3.9	$\Xi^-\pi^0$	28 events	290
				ΛK^-	seen	211

*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, δx, i.e., $\delta x\to S\delta x$. 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 ideogram in Stable Particle Data Card Listings.

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

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

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

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

e. See note in Stable Particle Data Card Listings.

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

g. Assumes rate for $\Xi^-\to\Sigma^0e^-\nu$ small compared with $\Xi^-\to\Lambda e^-\nu$.

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

i. A contradictory unpublished result of ~ 9×10^{-9} (with 6 events seen) has been reported by Carithers et al. See note in Stable Particle Data Card Listings.

ADDENDUM TO

Stable Particle Table

	Magnetic moment	μ Decay parameters [a]
e	$1.001\ 159\ 6577 \pm .000\ 000\ 0035$ $\frac{e\hbar}{2m_e c}$	
μ	$1.001\ 166\ 16 \pm .000\ 000\ 31$ $\frac{e\hbar}{2m_\mu c}$	$\rho = 0.752\pm0.003$ $\eta = -0.12 \pm0.21$ $\xi = 0.972\pm0.013$ $\delta = 0.755\pm0.009$ $h = 1.00\pm0.13$ $\lvert g_A/g_V \rvert = 0.86^{+0.33}_{-0.11}$ $\phi = 180° \pm 15°$

$K^\pm$

Mode	Partial rate (sec^{-1})	
$\mu\nu$	$(51.35\pm0.19)10^6$	$S=1.2^*$
$\pi\pi^0$	$(17.02\pm0.15)10^6$	$S=1.1^*$
$\pi\pi^+\pi^-$	$(4.52\pm0.02)10^6$	$S=1.1^*$
$\pi\pi^0\pi^0$	$(1.40\pm0.04)10^6$	$S=1.4^*$
$\mu\pi^0\nu$	$(2.62\pm0.08)10^6$	$S=1.9^*$
$e\pi^0\nu$	$(3.92\pm0.05)10^6$	$S=1.1^*$

$\Delta I = \frac{1}{2}$ rule for $K^\pm \rightarrow 3\pi$

$\pi^+\pi^+\pi^-$ $c_g = -.214\pm.005$ $S=1.7^*$

$\pi^-\pi^+\pi^-$ $c_g = -.214\pm.007$ $S=2.7^*$

$\pi^+\pi^0\pi^0$ $c_g = .523\pm.023$ $S=1.4^*$

See also Stable Particle Data Card Listings and Appendix I

Form factors for leptonic decays

$\lambda_+^e = 0.028\pm0.005$

See Stable Particle Data Card Listings for ξ and λ_+^μ.

K_S^0

Mode	Partial rate (sec^{-1})	
$\pi^+\pi^-$	$(0.780\pm.008)10^{10}$	$S=1.9^*$
$\pi^0\pi^0$	$(0.353\pm.005)10^{10}$	$S=1.4^*$

K_L^0

Mode	Partial rate (sec^{-1})	
$\pi^0\pi^0\pi^0$	$(4.15\pm0.16)10^6$	$S=1.3^*$
$\pi^+\pi^-\pi^0$	$(2.43\pm0.05)10^6$	
$\pi\mu\nu$	$(5.19\pm0.12)10^6$	$S=1.1^*$
$\pi e\nu$	$(7.48\pm0.13)10^6$	$S=1.1^*$
$\pi^+\pi^-$	$(3.02\pm0.10)10^4$	
$\pi^0\pi^0$	$(1.82\pm0.38)10^4$	$S=1.5^*$

CP violation parameters

$\lvert\eta_{+-}\rvert = (1.98\pm0.04)10^{-3}$, $\phi_{+-} = (42\pm3)°$ $S=1.1^*$

$\lvert\eta_{00}\rvert = (2.09\pm0.10)10^{-3}$, $\phi_{00} = (43\pm19)°$ $S=1.2^*$

$d_\delta = (.33\pm.04)10^{-2}$ $S=1.5^*$

$f_y^2 < 0.27$

$\Delta I = \frac{1}{2}$ rule for $K_L^0 \rightarrow 3\pi$

$\pi^+\pi^-\pi^0$ $c_g = .60\pm.02$ $S=2.7^*$

See Data Cards & App. I

$\Delta S = -\Delta Q$

Re $x = -.003\pm.027$ $S=1.6^*$

Im $x = -.005\pm.038$ $S=1.2^*$

Form Factors for leptonic decays

$\lambda_+^e = 0.025\pm0.005$ $S=1.3^*$

See Stable Particle Data Card Listings for $\lambda_\mp^\mu$ and ξ

η

Mode	Asymmetry parameter
$\pi^+\pi^-\pi^0$	$^e(0.24\pm.40)\%$ $S=2.0^*$
$\pi^+\pi^-\gamma$	$(0.61\pm.54)\%$

	Magnetic moment $(e\hbar/2m_p c)$		Decay parameters [b] Measured α	Measured ϕ(degree)	Derived γ	Derived Δ (degree)	g_A/g_V [b]	g_V/g_A [b]
p	$2.792782 \pm .000017$							
n	$-1.913148 \pm .000066$	$pe^-\nu$					$-1.248\pm.010$ $\delta = (181.1\pm1.3)°$	
Λ	$-0.67 \pm .06$	$p\pi^-$	0.647 ± 0.013	$(-6.5\pm3.5)°$	0.76	$\left(7.6^{+4.0}_{-4.1}\right)°$		
		$n\pi^0$	0.651 ± 0.045					
		$pe\nu$					-0.66 ± 0.06 $S=1.2^*$	
Σ^+	$2.59 \pm .46$	$p\pi^0$	-0.984 ± 0.017	$(22\pm90)°$	0.17	$(184\pm15)°$		
		$n\pi^+$	$+0.066\pm0.016$	$(167\pm20)°$ $S=1.1^*$	-0.97	$\left(-73^{+136}_{-10}\right)°$		
		$p\gamma$	$-1.03^{+.52}_{-.42}$					
Σ^-		$n\pi^-$	-0.069 ± 0.008	$(10\pm15)°$	0.98	$\left(249^{+12}_{-115}\right)°$		
		$ne^-\nu$					See Data Cds.	
		$\Lambda e^-\nu$						0.37 ± 0.20
Ξ^0	-	$\Lambda\pi^0$	-0.39 ± 0.09 $S=1.2^*$	$(25\pm21)°$ $S=1.3^*$	0.84	$\left(225^{+16}_{-35}\right)°$		
Ξ^-	$-1.93 \pm .75$	$\Lambda\pi^-$	-0.40 ± 0.03	$(-4\pm8)°$ $S=1.1^*$	0.91	$\left(170^{+18}_{-17}\right)°$		

ADDENDUM TO

Stable Particle Table *(cont'd)*

*S = scale factor. Quoted error includes scale factor; see footnote to main Stable Particle Table for definition.

a. $|g_A/g_V|$ defined by

$$g_V{}^2 = |C_V|^2 + |C'_V|^2,$$

$$g_A{}^2 = |C_A|^2 + |C'_A|^2,$$

$$\Sigma \langle \bar{e} | \Gamma_i | \mu \rangle \langle \bar{\nu} | \Gamma_i (C_i + C'_i \gamma_5) | \nu \rangle ;$$

ϕ defined by $\cos\phi = -R_e(C^*_A C'_V + C'_A C^*_V)/g_A g_V$ [for more details, see text Section IV E]

b. The definition of these quantities is as follows [for more details on sign convention, see text Section IV H]:

$$\alpha = \frac{2|s||p|\cos\Delta}{|s|^2 + |p|^2} ;$$

$$\beta = \frac{-2|s||p|\sin\Delta}{|s|^2 + |p|^2} .$$

$$\beta = \sqrt{1-\alpha^2}\sin\phi;$$

$$\gamma = \sqrt{1-\alpha^2}\cos\phi .$$

g_A/g_V defined by $\langle B_f | \gamma_\lambda (g_V - g_A \gamma_5) | B_i \rangle$;

δ defined by $g_A/g_V = |g_A/g_V| e^{i\delta}$.

c. The definition of the slope parameter of the Dalitz plot is as follows:

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

d. The definition for the charge asymmetry is as follows:

$$\delta = \frac{\Gamma(K_L^0 \rightarrow \ell^+) - \Gamma(K_L^0 \rightarrow \ell^-)}{\Gamma(K_L^0 \rightarrow \ell^+) + \Gamma(K_L^0 \rightarrow \ell^-)}$$

e. See note in Stable Particle Data Card Listings.

f. The quantity y^2 is defined as follows:

$$y^2 = \frac{\Gamma(K_S^0 \rightarrow \pi^+\pi^-\pi^0)}{\Gamma(K_L^0 \rightarrow \pi^+\pi^-\pi^0)}$$

where CPT is assumed valid.

Meson Table

April 1973

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(1).

Quantities in italics have changed by more than one (old) standard deviation since April 1972.

Name G╲I 0 1 − ω/φ π + η ρ	$I^G(J^P)C_n$ ├─┤estab.	Mass M (MeV)	Full Width Γ (MeV)	M^2 $\pm\Gamma M$(a) $(\mathrm{GeV})^2$	Partial decay mode Mode	 Fraction (%) [Upper limits are 1σ (%)]		 p or p_{max}(b) (MeV/c)
$\pi^\pm(140)$ $\pi^0(135)$	$1^-(0^-)+$	139.57 134.96	0.0 7.8 eV ±.9 eV	0.019483 0.018217	See Stable Particle Table			
$\eta(549)$	$0^+(0^-)+$	548.8 ±0.6	2.63 keV ±.58 keV	0.301 ±.000	All neutral $\pi^+\pi^-\pi^0 + \pi^+\pi^-\gamma$	71 29	See Stable Particle Table	
ε	$0^+(0^+)+$	$\lesssim 700$ (c)	$\gtrsim 600$ (c)		$\pi\pi$			
Existence of pole not established. See note on ππ S wave¶.								
$\rho(770)$	$1^+(1^-)-$	770 § ±5	146 § ±10	0.593 ±.112	$\pi\pi$ e^+e^- $\mu^+\mu^-$	≈100 0.0043±.0005 (d) 0.0067±.0012 (d)		359 385 370
					For upper limits, see footnote (e)			
$\omega(784)$	$0^-(1^-)-$	783.8 (f) ±0.3 S=1.3*	9.8 ±.5 S=1.1*	0.614 ±.008	$\pi^+\pi^-\pi^0$ $\pi^+\pi^-$ $\pi^0\gamma$ e^+e^-	89.6±0.6 1.3±0.3 9.1±0.5 0.0076±.0017	S=1.1* S=1.5* S=1.9*	328 366 380 392
					For upper limits, see footnote (g)			
⇉ $\eta'(958)$ or X^0	$0^+(0^-)+$	958.1 ±0.4 S=1.4*	< 2	0.918 <.002	$\eta\pi\pi$ $\pi^+\pi^-\gamma$ (mainly $\rho^0\gamma$) $\gamma\gamma$	*71.8±3.9* *26.2±3.5* 1.9±0.3	*S=2.0** *S=2.2** 	234 458 479
					For upper limits, see footnote (h)			
$\delta(970)$ formerly called $\pi_N(975)$	$1^-(0^+)+$	∿ 970	50 § ±30	0.941 ±.049	$\eta\pi$			311
Possibly a virtual bound state of the I = 1 $K\bar{K}$ system¶.								
→ S^*	$0^+(0^+)+$	∿ 997 (c)	50-150 (c)	0.993	$\pi\pi$ $K\bar{K}$			479 near threshold
See notes on ππ and $K\bar{K}$ S wave¶.								
$\Phi(1019)$	$0^-(1^-)-$	1019.6 ±0.3 S=1.9	4.2 ±.2	1.040 ±.004	K^+K^- K_LK_S $\pi^+\pi^-\pi^0$ (incl. $\rho\pi$) $\eta\gamma$ e^+e^- $\mu^+\mu^-$	*46.8±2.7* *35.0±2.8* 15.2±3.6 3.0±1.1 .032±.003 .025±.003	*S=1.6* *S=1.6** S=1.8* S=1.6* S=1.9* 	127 110 462 362 510 499
					For upper limits, see footnote (i)			
⇶ $A_1(1100)$	$1^-(1^+)+$	∿ 1100	200-400	1.21	$\rho\pi$	∿ 100		253
Broad enhancement in the $J^P=1^+$ ρπ partial wave; not a Breit-Wigner resonance¶.								
⇉ $B(1235)$	$1^+(1^+)-$	1237 § ±10	120 § ±20	1.53 ±.12	$\omega\pi$	only mode seen		351
					For upper limits, see footnote (j)			

Meson Table *(cont'd)*

Name G\I 0 1 − ω/φ π + η ρ	$I^G(J^P)C_n$ ├─┤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)**
f(1270)	$0^+(2^+)+$	1270	163	1.61	$\pi\pi$	∿ 80	619
		±5§	±15§	±.21	$2\pi^+2\pi^-$	5±2§	556
					$K\bar{K}$	5±3§	394
D(1285)	$0^+(A\ )+$	1286	30	1.65	$K\bar{K}\pi$	seen	305
		±10§	±20§	±.03	$\eta\pi\pi$	seen	484
					†[$\delta(970)\pi$	seen]	250
	$J^P = 0^-, 1^+, 2^-$, with 1^+ favoured				$2\pi^+2\pi^-$ (prob. $\rho^0\pi^+\pi^-$)	seen	565
A_2(1310)	$1^-(2^+)+$	1310	100	1.72	$\rho\pi$	*72.4±2.1*	413
		±10§	±10§	±.13	$\eta\pi$	15.3±1.3	529
					$\omega\pi\pi$	*7.6±2.2*	353
					$\bar{K}K$	*4.7±0.6*	428
					$\eta'(958)\pi$	<1	279
E(1420)	$0^+(A\ )+$	1416	60	2.01	$K\bar{K}\pi$	∿ 40	421
		±10§	±20§	±.08	†[$K^*\bar{K} + \bar{K}^*K$	∿ 20]	131
					$\eta\pi\pi$	∿ 60	564
					†[$\delta(970)\pi$	possibly seen]	356
f′(1514)	$0^+(2^+)+$	1516	*40*	2.29	$K\bar{K}$	*only mode seen*	572
		±3	*±10*	±.06			
					For upper limits, see footnote (k)		
F_1(1540)	$1(A\ )$	1540	40	2.37	$K^*\bar{K} + \bar{K}^*K$	only mode seen	321
		±5	±15	±.06			
Evidence based on only one experiment							
					4π	only mode seen	
ρ′(1600)	$1^+(1^-)-$	∿ 1600	∿ 500	2.56	†[$\rho\pi\pi$	∿80]	575
Resonance interpretation uncertain.					$\pi\pi$	< 1 (p)¶	788
					For upper limits, see footnote (p)		629
A_3(1640)	$1^-(2^-)+$	∿ 1645	100-400	2.71	$f\pi$	∿ 100	310
Broad enhancement in the $J^P = 2^-$ $f\pi$ partial wave; not a Breit-Wigner resonance.¶							
ω(1675)	$0^-(N\ )-$	1664	141	2.77	$\rho\pi$	dominant	645
formerly called		±13	±17	±.23	3π	possibly observed	804
φ(1675)		S=1.2*			5π	10±10	777
g(1680)	$1^+(3^-)-$	1680	160	2.82	2π	∿ 40 } (ℓ)	828
		±20§	±30§	±.27	4π (incl. $\pi\pi\rho, \rho\rho, A_2\pi, \omega\pi$)	∿ 50 } (ℓ)	781
					$K\bar{K}$	∿ 3 } (ℓ)	677
J^P, M and Γ from the 2π mode$^{(\ell)}$.					$K\bar{K}\pi$ (incl. $K^*\bar{K}$)	∿ 3 } (ℓ)	617
See note (1) for possible heavier states.							
K^+(494)	$1/2(0^-)$	493.71		0.244	See Stable Particle Table		
K^0(498)		497.71		0.248			
K^*(892)	$1/2(1^-)$	891.7	50.1	0.795	$K\pi$	≈ 100	288
		±0.5	±1.1	±.045	$K\pi\pi$	< 0.2	216
						< 0.16	309
		(Charged mode; $m^0 - m^\pm = 6.1\pm1.5$ MeV)					

Meson Table *(cont'd)*

Name

G \ I	0	1
−	ω/φ	π
+	η	ρ

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)
κ	1/2(0$^+$)	δ_0^1 is near 90°, with slow variation, in mass region 1200-1400 MeV.						
See note on Kπ S wave¶.								
⇉								
Q { K_A(1240) or C	1/2(1$^+$)	1242 ±10	127 ±25	1.54 ±.16	Kππ	only mode seen		
		seen in $\bar{p}p$ at rest			†[$K^*\pi$	large]		
K_A(1280 to 1400)	1/2(1$^+$)	1280 to 1400			†[Kρ	seen]		
See note (m).					†[$K(\pi\pi)_{\ell=0}$	possibly seen]		
→								
K_N(1420)	1/2(2$^+$)	1421 ±5§	100 ±10§	2.02 ±.14	Kπ	55.0±3.3	S=1.2*	616
					$K^*\pi$	29.5±2.7		415
					Kρ	9.2±2.9	S=1.2*	319
		See note (n).			Kω	4.4±1.7		304
					Kη	2.0±1.8		482
⇉								
L(1770)	1/2(A)	1765 ±10§	140 ±50§	3.11 ±.25	Kππ	dominant		788
					Kπππ	seen		757
					†[K_N(1420)π and other subreactions¶]			
	$J^P=2^-$ favoured, 1^+ and 3^+ not excluded.							
→								

See note (1) for possible heavier states.

(1) Contents of Meson Data Card Listings

Non-strange (Y = 0)							Strange (|Y| = 1)	
entry	$I^G(J^P)C_n$	entry	$I^G(J^P)C_n$		entry	$I^G(J^P)C_n$	entry	I (J^P)
π (140)	$1^-(0^-)+$	→ η_N (1080)	0^+(N)+	R-region {	A_3 (1640)	$1^-(2^-)+$	K (494)	1/2(0^-)
η (549)	$0^+(0^-)+$	A_1 (1100)	$1^-(1^+)+$	R-region	ω (1675)	0^-(N)−	K^* (892)	1/2(1^-)
ε (600)	$0^+(0^+)+$	→ M (1150)		R-region	g (1680)	$1^+(3^-)-$	κ	1/2(0^+)
ρ (770)	$1^+(1^-)-$	→ $A_{1.5}$(1170)	1^-	R-region	→ X (1690)	$^-$	→ K_A(1175)	3/2
ω (784)	$0^-(1^-)-$	B (1235)	$1^+(1^+)-$		→ X (1795)	1	→ K_A(1265)	3/2
→ M (940)		F (1270)	$0^+(2^+)+$		→ η/ρ(1830)	$^+$	Q	1/2(1^+)
→ M (953)	$^+$	D (1285)	0^+(A)+		→ ω/π(1830)	$^-$	K_N(1420)	1/2(2^+)
η′ (958)	$0^+(0^-)+$	A_2 (1310)	$1^-(2^+)+$		→ S (1930)		→ K_N(1660)	1/2
δ (970)	$1^-(0^+)+$	E (1420)	0^+(A)+		→ ρ (2100)	1^+	→ K_N(1760)	1/2
→ H (990)	0^-(A)−	→ X (1430)	0		→ T (2200)	1	L (1770)	1/2(A)
S^*(1000)	$0^+(0^+)+$	→ X (1440)	1		→ ρ (2275)	1^+	→ K_N(1850)	
φ (1019)	$0^-(1^-)-$	f′ (1514)	$0^+(2^+)+$		→ U (2360)	1	→ K^*(2200)	
→ M (1033)		F_1 (1540)	1 (A)		→ $N\bar{N}$ (2375)	0	→ K^*(2800)	
→ B_1(1040)	1^+	ρ′ (1600)	$1^+(1^-)-$		→ X(2500-3600)			

Meson Table *(cont'd)*

$\rightarrow$ indicates an entry in Meson Data Card Listings not entered in the Meson Table. We do not regard these as established resonances.

¶ 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 $(M - i\Gamma/2)$. For both ε and S^* the pole is on Riemann Sheet 2.

(d) The e^+e^- branching ratio is from $e^+e^- \rightarrow \pi^+\pi^-$ 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, $\Gamma(\rho^0 \rightarrow \mu^+\mu^-) = \Gamma(\rho^0 \rightarrow e^+e^-) \times$ phase space correction.

(e) Empirical limits on fractions for other decay modes of $\rho(765)$ are $\pi^\pm\gamma < 0.5\%$, $\pi^\pm\eta < 0.8\%$, $\pi^+\pi^+\pi^-\pi^- < 0.15\%$, $\pi^\pm\pi^+\pi^-\pi^0 < 0.2\%$.

(f) Note that experiments with final state $K_SK_S\omega$ ($\bar{p}p$ at rest) give $M_\omega = 780.6 \pm 0.5$¶.

(g) Empirical limits on fractions for other decay modes of $\omega(784)$ are $\pi^+\pi^-\gamma < 5\%$, $\pi^0\pi^0\gamma < 1\%$, η + neutral(s) $< 1.5\%$, $\mu^+\mu^- < 0.02\%$, $\pi^0\mu^+\mu^- < 0.2\%$, $\eta\gamma < 0.5\%$.

(h) Empirical limits on fractions for other decay modes of $\eta'(958)$: $\pi^+\pi^- < 2\%$, $\pi^+\pi^-\pi^0 < 5\%$, $\pi^+\pi^+\pi^-\pi^- < 1\%$, $\pi^+\pi^+\pi^-\pi^-\pi^0 < 1\%$, $6\pi < 1\%$, $\pi^+\pi^-e^+e^- < 0.6\%$, $\pi^0e^+e^- < 1.3\%$, $\eta e^+e^- < 1.1\%$, $\pi^0\rho^0 < 4\%$, $\pi^0\omega < 8\%$.

(i) Empirical limits on fractions for other decay modes of $\phi(1019)$ are $\pi^+\pi^- < 0.03\%$, $\pi^+\pi^-\gamma < 4\%$, $\omega\gamma < 5\%$, $\rho\gamma < 2\%$, $\pi^0\gamma < 0.35\%$, $2\pi^+2\pi^-\pi^0 < 9\%$.

(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'(1514) are $\pi^+\pi^- < 20\%$, $\eta\eta < 50\%$, $\eta\pi\pi < 30\%$, $K\bar{K}\pi + K^*\bar{K} < 35\%$, $2\pi^+2\pi^- < 32\%$.

(ℓ) We assume as a working hypothesis that peaks with $I^G = 1^+$ observed around 1.7 GeV all come from g(1680). For indications to the contrary see Meson Data Card Listings.

(m) See Q-region note in Meson Data Card Listings. Some investigators see a broad enhancement in mass ($K\pi\pi$) from 1250-1400 MeV (the Q region), and others see structure. The $K\eta$, $K\omega$, and $K\pi$ are less than a few percent.

(n) The tabulated mass of 1421 MeV comes only from charged $K_N(1420) \rightarrow K\pi$ measurements; the average of the neutral $K_N(1420)$ mass is 1423 MeV. $K\pi\pi$ mode can be contaminated with diffractively produced $Q^\pm$.

(o) Empirical limits on fractions for other decay modes of f(1270) are $\eta\pi\pi < 15\%$; $K^0K^-\pi^+$ + c.c. $< 6\%$.

(p) The tiny partial width for $\rho' \rightarrow \pi\pi$ ($\Gamma < 2$ MeV) is based on an OPE model.¶ Empirical limits are $\pi\pi < 20\%$, $K\bar{K} < 8\%$.

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 semi-colon.

$(J^P)C_n$	Nonet members	$\theta_{lin.}$	$\theta_{quadr.}$
$(0^-)+$	π, K, η; η'	24 ± 1°	10 ± 1°
$(1^-)-$	ρ, K^*, ϕ; ω	36 ± 1°	39 ± 1°
$(2^+)+$	A_2, $K_N(1420)$, f'; f	29 ± 2°	31 ± 2°

Baryon Table

April 1973

Baryon States for which information can be found in the Data Card Listings. The name, the mass, the quantum numbers, and the status are shown. Those states with four or three stars can be found in the following 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(940)	P11	****	Δ(1236)	P33	****	Λ(1115)	P01	****	Σ(1190)	P11	****	Ξ(1320)	P11	****
N(1470)	P11	****	Δ(1650)	S31	****	Λ(1330)		Dead	Σ(1385)	P13	****	Ξ(1530)	P13	****
N(1520)	D13	****	Δ(1670)	D33	***	Λ(1405)	S01	****	Σ(1440)	PE	Dead	Ξ(1630)		**
N(1535)	S11	****	Δ(1690)	P33	*	Λ(1520)	D03	****	Σ(1480)	PE	*	Ξ(1820)		***
N(1670)	D15	****	Δ(1890)	F35	***	Λ(1670)	S01	****	Σ(1620)	S11	**	Ξ(1940)		***
N(1688)	F15	****	Δ(1910)	P31	***	Λ(1690)	D03	****	Σ(1620)	P11	**	Ξ(2030)		**
N(1700)	S11	****	Δ(1950)	F37	****	Λ(1750)	P01	**	Σ(1620)	PE	**	Ξ(2250)		*
N(1700)	D13	**	Δ(1960)	D35	*	Λ(1815)	F05	****	Σ(1670)	D13	****	Ξ(2500)		**
N(1780)	P11	***	Δ(2160)	P33	*	Λ(1830)	D05	***	Σ(1670)	PE	**			
N(1860)	P13	***	Δ(2420)	H311	***	Λ(1860)	P03	**	Σ(1690)	PE	**			
N(1990)	F17	**	Δ(2850)		***	Λ(1870)	S01	**	Σ(1750)	S11	***			
N(2040)	D13	**	Δ(3230)		***	Λ(2010)	D03	**	Σ(1765)	D15	****	Ω(1670)	P03	****
N(2100)	S11	*				Λ(2020)	F07	**	Σ(1840)	P13	*			
N(2100)	D15	*				Λ(2100)	G07	****	Σ(1880)	P11	**			
N(2175)	F15	*				Λ(2110)		*	Σ(1915)	F15	****			
N(2190)	G17	***	Z0(1780)	P01	*	Λ(2350)		****	Σ(1940)	D13	***			
N(2220)	H19	***	Z0(1865)		*	Λ(2585)		***	Σ(2000)	S11	*			
N(2650)		***	Z1(1900)	P13	*				Σ(2030)	F17	****			
N(3030)		***	Z1(2150)		*				Σ(2070)	F15	*			
N(3245)		*	Z1(2500)		*				Σ(2080)	P13	**			
N(3690)		*							Σ(2100)	G17	**			
N(3755)		*							Σ(2250)		****			
									Σ(2455)		***			
									Σ(2620)		***			
									Σ(3000)		**			

**** 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, on possible Z^{*}'s, and on Y^{*}'s 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) ⊢⊣ estab.	π or K Beam T(GeV) p(GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass M^b (MeV)	Full Width Γ^b (MeV)	M^2 $\pm\Gamma M^c$ (GeV^2)	Partial decay mode Mode	 Fraction %	 p or p_{max} ^{d} (MeV/c)
p n	1/2(1/2$^+$)		938.3 939.6		0.880 0.883	See Stable Particle Table		
N' (1470)	1/2(1/2$^+$) P'_{11}	T=0.53πp p=0.66 σ=27.8	~1470	165 to 300	2.16 ±0.41	Nπ Nππ [Nε [Δπ [Nρ $p\gamma^g$ $n\gamma^g$	60 40 5-30]^e 20-30]^e ~7]^e 0.05 0.0	420 368 173 435 435
N'(1520)	1/2(3/2$^-$) D'_{13}	T=0.61 p=0.74 σ=23.5	1510 to 1540	105 to 150	2.31 ±0.18	Nπ Nππ [Nε [Nρ [Δπ Nη $p\gamma^g$ $n\gamma^g$	50 ~50 0-2]^e 7-25]^e 15-40]^e 0.2-1.4 0.55 0.30	456 410 224 471 471
N'(1535)	1/2(1/2$^-$) S'_{11}	T=0.64 p=0.76 σ=22.5	1500 to 1600	50 to 160	2.36 ±0.18	Nπ Nη Nππ [Nρ $p\gamma^g$ $n\gamma^g$	35 55 ~10 1-2]^e 0.2-0.4 0.12	467 182 422 481 481

Baryon Table *(cont'd)*

Particle^a	I (J^P) ⊢⊣ estab.	π or K Beam T(GeV) p(GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass M^b (MeV)	Full Width Γ^b (MeV)	M^2 $\pm\Gamma M^c$ (GeV^2)	Partial decay mode Mode	 Fraction %	 p or p_{max} ^{d} (MeV/c)
$N'(1670)^i$	$\underline{1/2(5/2^-)}$ D'_{15}	T=0.87 p=1.00 σ=15.6	1670 to 1685	115 to 175	2.79 ±0.24	$N\pi$ $N\pi\pi$ $[\Delta\pi$ ΛK $N\eta$ $p\gamma^g$ $n\gamma^g$	40 60 50-60]^e <1 <1^j 0.01 0.02	560 525 357 200 368 572 572
$N'(1688)^i$	$\underline{1/2(5/2^+)}$ F'_{15}	T=0.90 p=1.03 σ=14.9	1680 to 1690	105 to 180	2.85 ±0.21	$N\pi$ $N\pi\pi$ $[N\epsilon$ $[N\rho$ $[\Delta\pi$ ΛK $N\eta$ $p\gamma^g$ $n\gamma^g$	60 40 12]^e 15]^e 13-40]^e <0.1 <0.3^j 0.20 0.01	572 538 340 372 231 388 583 583
$N''(1700)^i$	$\underline{1/2(1/2^-)}$ S''_{11}	T=0.92 p=1.05 σ=14.3	1665 to 1765	100 to 300	2.89 ±0.42	$N\pi$ $N\pi\pi$ $[N\epsilon$ $[N\rho$ ΛK $N\eta$ $p\gamma^g$ $n\gamma^g$	60 25-30]^e 10-20]^e 5 ~3^j 0.05-0.1 0.05	580 547 355 250 340 591 591
$N''(1780)^i$	$\underline{1/2(1/2^+)}$ P''_{11}	T=1.07 p=1.20 σ=12.2	1650 to 1860	50 to 350	3.17 ±0.51	$N\pi$ $N\pi\pi$ $[N\epsilon$ $[\Delta\pi$ ΛK $N\eta$ $p\gamma^g$ $n\gamma^g$	~20 30-40]^{e,h} 25-35]^{e,h} <7 10-20^j 0.01 0.01	633 603 440 445 353 476 643 643
N(1860)	$\underline{1/2(3/2^+)}$ P_{13}	T=1.22 p=1.36 σ=10.4	1770 to 1860	180 to 330	3.46 ±0.57	$N\pi$ $N\pi\pi$ $[N\rho$ ΛK $N\eta$	25 55-65]^{e,h} ~5 ~4^j	685 657 366 437 545
N(2190)	$\underline{1/2(7/2^-)}$ G_{17}	T=1.94 p=2.07 σ=6.21	2000 to 2260	270 to 325	4.80 ±0.67	$N\pi$ $N\pi\pi$	25	888 868
N(2220)	$\underline{1/2}(9/2^+)$ H_{19}	T=2.00 p=2.14 σ=5.97	2200 to 2245	260 to 330	4.93 ±0.65	$N\pi$ $N\pi\pi$	15	905 887
N(2650)	$\underline{1/2}$(?$^-$)	T=3.12 p=3.26 σ=3.67	~2650	~360	7.02 ±0.95	$N\pi$ $N\pi\pi$	(J+1/2)x =0.45^f	1154 1140
N(3030)	$\underline{1/2}$(?)	T=4.27 p=4.41 σ=2.62	~3030	~400	9.18 ±1.21	$N\pi$ $N\pi\pi$	(J+1/2)x =0.05^f	1366 1354
$\Delta'(1236)^m$	$\underline{3/2(3/2^+)}$ P'_{33}	T=0.195 (++) p=0.304 σ=91.8	1230 to 1236	110 to 122	1.53 ±0.14	$N\pi$ $N\pi^+\pi^-$ $N\gamma^g$	99.4 0 ~0.6	231 90 262
		Pole position^m: $M - i\Gamma/2 = (1211.6\pm0.7) - i(49.5\pm1.8)$						
$\Delta(1650)$	$\underline{3/2(1/2^-)}$ S_{31}	T=0.83 p=0.96 σ=16.4	1615 to 1695	130 to 200	2.72 ±0.28	$N\pi$ $N\pi\pi$ $[N\rho$ $[\Delta\pi$ $N\gamma^g$	28 72 8-16]^e 26-32]^e 0.30	547 511 558 340 558

Baryon Table *(cont'd)*

Particle[a]	I (J^P) ⊢⊣ estab.	π or K Beam T(GeV) p(GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass M^b (MeV)	Full Width Γ^b (MeV)	M^2 $\pm\Gamma M^c$ (GeV^2)	Partial decay mode Mode	 Fraction %	 p or p_{max} [d] (MeV/c)
$\Delta(1670)$	$3/2(3/2^-)$ D_{33}	T=0.87 p=1.00 σ=15.6	1650 to 1720	175 to 300	2.79 ±0.40	$N\pi$ $N\pi\pi$ $[\Delta\pi$ $N\gamma^g$	15 $22\text{-}30]^e$ 0.05	560 525 357 572
$\Delta(1890)$	$3/2(5/2^+)$ F_{35}	T=1.28 p=1.42 σ=9.88	1840 to 1920	200 to 350	3.57 ±0.49	$N\pi$ $N\pi\pi$ $[N\rho$ $N\gamma^g$	17 $55\text{-}70]^e$ 0.03	704 677 403 712
$\Delta(1910)$	$3/2(1/2^+)$ P_{31}	T=1.33 p=1.46 σ=9.54	1780 to 1935	200 to 340	3.65 ±0.52	$N\pi$ $N\pi\pi$ $[N\rho$ $[\Delta\pi$ $N\gamma^g$	25 $3\text{-}16]^e$ $4\text{-}16]^e$ 0.03	716 691 429 543 725
$\Delta(1950)$	$3/2(7/2^+)$ F_{37}	T=1.41 p=1.54 σ=8.90	1930 to 1980	170 to 270	3.80 ±0.44	$N\pi$ $N\pi\pi$ $[N\rho$ $[\Delta\pi$ $N\gamma^g$ ΣK $\Sigma(1385)K$	45 $8\text{-}12]^e$ $14\text{-}19]^e$ 0.15 ~2 1.4	741 716 471 571 749 460 232
$\Delta(2420)$	$3/2(11/2^+)$ ⊢⊣	T=2.50 p=2.64 σ=4.68	2320 to 2450	270 to 350	5.86 ±0.75	$N\pi$ $N\pi\pi$	11 >20	1023 1006
$\Delta(2850)$	$3/2(\ ?^+\ )$	T=3.71 p=3.85 σ=3.05	~2850	~400	8.12 ±1.14	$N\pi$ $N\pi\pi$	(J+1/2)x $=0.25^f$	1266 1254
$\Delta(3230)$	$3/2(\ ?\ )$	T=4.94 p=5.08 σ=2.25	~3230	~440	10.4 ±1.4	$N\pi$ $N\pi\pi$	(J+1/2)x $=0.05^f$	1475 1464
Z^*	Evidence for states with hypercharge 2 is controversial. See the Baryon Data Card Listings for discussion and display of data.							
Λ	$0(1/2^+)$		1115.6		1.24	See Stable Particle Table		
$\Lambda'(1405)$	$0(1/2^-)$ S'_{01}	p< 0 K^-p	1405_n ±5	40_n ±10	1.97 ±0.06	$\Sigma\pi$	100	142
$\Lambda'(1520)$	$0(3/2^-)$ D'_{03}	p=0.389 σ=84.5	1518_n ±2	16_n ±2	2.30 ±0.02	$N\bar{K}$ $\Sigma\pi$ $\Lambda\pi\pi$ $\Sigma\pi\pi$	45±1 41±1 10±.5 1.0±.1	234 258 250 140
$\Lambda''(1670)$	$0(1/2^-)$ S''_{01}	p=0.74 σ=28.5	~1670	15 to 38	2.79 ±0.04	$N\bar{K}$ $\Lambda\eta$ $\Sigma\pi$	15-35 15-25 30-50	410 64 393
$\Lambda''(1690)$	$0(3/2^-)$ D''_{03}	p=0.78 σ=26.1	~1690	27 to 85	2.86 0.09	$N\bar{K}$ $\Sigma\pi$ $\Lambda\pi\pi$ $\Sigma\pi\pi$	20-30 40-70 <25 <25	429 409 415 352
$\Lambda'(1815)$	$0(5/2^+)$ F'_{05}	p=1.05 σ=16.7	1820 $\pm5^n$	64 to 104	3.30 ±0.15	$N\bar{K}$ $\Sigma\pi$ $\Sigma(1385)\pi$	61 11 15-20	542 508 362
$\Lambda'(1830)$	$0(5/2^-)$ D'_{05}	p=1.09 σ=15.8	1810 to 1840	60 to 150	3.33 ±0.19	$N\bar{K}$ $\Sigma\pi$ $\Lambda\pi\pi$	~10 20-60 	554 519 536
$\Lambda(2100)$	$0(7/2^-)$ G_{07}	p=1.68 σ=8.68	~2100	60 to 140	4.41 ±0.22	$N\bar{K}$ $\Sigma\pi$ $\Lambda\eta$ ΞK $\Lambda\omega$	25 ~ 5 < 3 ~ 2 ~ 1	748 699 617 483 443

Baryon Table *(cont'd)*

Particle[a]	I (J^P) $\vdash\!\dashv$ estab.	π or K Beam T(GeV) p(GeV/c) $\sigma = 4\pi\lambda\!\!\!^-{}^2$ (mb)	Mass M^b (MeV)	Full Width Γ^b (MeV)	M^2 $\pm\Gamma M^c$ (GeV^2)	Partial decay mode Mode	 Fraction %	 p or p_{max} [d] (MeV/c)
$\Lambda(2350)$	0(?)	p=2.29 σ=5.85	~ 2350	140 to 324	5.52 ±0.55	$N\bar{K}$	(J+1/2)x =0.7[f]	913
$\Lambda(2585)$	0(?)	p=2.91 σ=4.37	~ 2585	~ 300	6.66 ±0.77	$N\bar{K}$	(J+1/2)x =1.0[f]	1058
Σ	$1(1/2^+)$		(+)1189.4 (0)1192.5 (-)1197.3		1.41 1.42 1.43	See Stable Particle Table		
$\Sigma'(1385)$	$1(3/2^+)P'_{13}$	$p<0$ K^-p	(+)1383±1 S=1.3* (-)1386±2 S=2.2*	(+) 34±2 S=2.0* (-)36±6 S=3.5*!	1.92 ±0.05	$\Lambda\pi$ $\Sigma\pi$	89±2 11±2	208 117
$\Sigma'(1670)^k$	$1(3/2^-)D'_{13}$	p=0.74 σ=28.5	~ 1670	35-65	2.79 ±0.08	$N\bar{K}$ $\Sigma\pi$ $\Lambda\pi$ $\Sigma\pi\pi$ $[\Lambda(1405)\pi]^e$ $\Lambda\pi\pi$	~8 ~40 ~12 5-15 	410 387 447 326 207 397
	Parameters here are obtained from partial wave analyses for a D_{13} resonance. Production experiments suggest two such states; see footnote k and the Baryon Data Card Listings.							
$\Sigma''(1750)$	$1(1/2^-)S''_{11}$	p=0.91 σ=20.7	1700 to 1790	50 to 100	3.05 ±0.13	$N\bar{K}$ $\Lambda\pi$ $\Sigma\eta$	seen seen seen	483 507 54
$\Sigma(1765)$	$1(5/2^-)D_{15}$	p=0.94 σ=19.6	1765[n] ±5	~120	3.12 ±0.21	$N\bar{K}$ $\Lambda\pi$ $\Lambda(1520)\pi$ $\Sigma(1385)\pi$ $\Sigma\pi$	~ 41 ~ 13 ~ 15 ~ 10 ~1	496 518 187 315 461
$\Sigma(1915)^i$	$1(5/2^+)F'_{15}$	p=1.25 σ=13.0	1900-1930	50-100	3.67 ±0.14	$N\bar{K}$ $\Lambda\pi$ $\Sigma\pi$	~14 ~ 6 ~ 6	612 619 568
Formation and production experiments do not agree on $\Sigma\pi/\Lambda\pi$ ratio.								
$\Sigma''(1940)$	$1(3/2^-)D''_{13}$	p=1.32 σ=12.0	~1940	~220	3.77 ±0.43	$N\bar{K}$ $\Lambda\pi$ $\Sigma\pi$	 seen seen	678 680 589
$\Sigma(2030)$	$1(7/2^+)F_{17}$	p=1.52 σ=9.93	~2030	100 to 170	4.12 ±0.27	$N\bar{K}$ $\Lambda\pi$ $\Sigma\pi$ ΞK	~ 20 ~ 20 ~ 4 < 2	700 700 652 412
$\Sigma(2250)$	1(?)	p=2.04 σ=6.76	~2250	100 to 230	5.06 ±0.37	$N\bar{K}$ $\Sigma\pi$ $\Lambda\pi$	(J+1/2)x =0.3[f]	849 842 799
$\Sigma(2455)$	1(?)	p=2.57 σ=5.09	~ 2455	~120	6.03 ±0.29	$N\bar{K}$	(J+1/2)x =0.2[f]	979
$\Sigma(2620)$	1(?)	p=2.95 σ=4.30	~ 2620	~175	6.86 ±0.46	$N\bar{K}$	(J+1/2)x =0.3[f]	1064
Ξ^ℓ	$1/2(1/2^+)$		(0)1314.9 (-)1321.3		1.73 1.75	See Stable Particle Table		
$\Xi(1530)^\ell$	$1/2(3/2^+)P_{13}$		(0) 1531.6±0.4 S=1.3* (-) 1535.0±0.6	(0) 9.1±0.5 (-) 12.9±4.1	2.34 ±0.01	$\Xi\pi$	100	144
$\Xi(1820)^\ell$	1/2(?)		1795 to 1870	12 to 99	3.31 ±0.10	$\Lambda\bar{K}$ $\Xi\pi$ $\Xi(1530)\pi$ $\Sigma\bar{K}$		396 413 234 306
	All four decay modes have been seen. Branching ratios not quoted because there may be more than one state here.							
$\Xi(1940)^\ell$	1/2(?)		1894 to 1961	42 to 140	3.72 ±0.18	$\Xi\pi$ $\Xi(1530)\pi$		499 336
	Seen in both final states; not clear if one, or more, states present.							
Ω^-	$0(3/2^+)$		1672.5		2.80	See Stable Particle Table		

Baryon Table *(cont'd)*

* Quoted error includes an S(scale) factor. See footnote to Stable Particle Table.

→ An arrow at the left of the Table indicates a candidate that has been omitted because the evidence for the existence of the effect and (or) for its interpretation as a resonance is open to considerable question. For convenience all Baryon States for which information exists in the Baryon Data Card Listings are listed at the beginning of the Baryon Table. In that list, states with only a one or two star (*) rating have been omitted from the Baryon Table; for additional information on such states, see the Baryon Data Card Listings.

a. For the baryon states, the name [such as N' (1470)] contains the mass, which may be different for each new analysis. The convention for using primes in the names is as follows: when there is more than one resonance on a given Argand diagram, the first has been designated with a prime, the second with a double prime, etc. The name (col. 1) is the same as can be found in large print in the Baryon Data Card Listings.

b. For M and Γ of most baryons we report here an interval instead of an average. Averages are appropriate if each result is based on independent measurements, but inappropriate here where the spread in parameters arises because different models or procedures have been applied to a common set of data. Where only one value is given it is either because only one experiment reports that state or because the various experiments agree. An error is quoted only when the various experiments averaged have taken into account the systematic errors.

c. For this column M is the rounded average which also appears in the name column. Γ is taken as the center of the interval given in the column labeled "Γ".

d. 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 using the averaged central mass values, without taking into account the widths of the resonances. For isobars, p is computed using the nominal isobar masses. If the isobar plus stable mass is less than the resonance mass, no value for p is given.

e. Square brackets indicate a sub-reaction of the previous unbracketed decay mode. Our estimate is from data in the Baryon Data Card Listings (where available) and from the isobar model Argand plots of HERNDON 72. See the Mini-Review preceding the N^* Data Card Listings.

f. This state has been seen only in total cross sections. J is not known; x is Γ_{el}/Γ.

g. The tabulated radiative fractions involve a sum over two helicities (1/2, 3/2). In the case of I=1/2 resonances, there are two distinct isospin couplings, whence γp and γn. For further information and conventions, see the Mini-Review preceding the Baryon Data Card Listings.

h. These values are particularly crude. Any naive estimate from the Argand plots of HERNDON 72 (see the Mini-Review preceding the N^* Data Card Listings) yields branching fractions the sum of which is greater than one. The values given have been scaled downward to be consistent with the branching fractions from other (non-isobar) channels.

i. Only information coming from partial-wave analyses has been used here. For the production experiments results see the Baryon Data Card Listings.

j. Value obtained in an energy-dependent partial-wave analysis which uses a t-channel-poles-plus-resonance parametrization. The values of the couplings obtained for the resonances may be affected by double counting.

k. In this energy region the situation is still confused. In addition to the $D_{13}(1670)$, formation experiments have found evidence for fairly narrow ($\Gamma \sim 50$ MeV) S_{11} and/or P_{11} states near 1620 MeV. It is not clear how many such states really exist. No one has reported a strong coupling of any of these states to $\bar{K}N$, but there is much disagreement about branching ratios $\pi\Lambda$ and $\pi\Sigma$.

ℓ. Only $\Xi(1530)$ is firmly established; information on the other states comes from experiments that have poor statistics due to the fact that the cross sections for S=-2 states are very low. For Ξ states, because of the meager statistics, we lower our standards and tabulate resonant effects if they have at least a four-standard-deviation statistical significance and if they are seen by more than one group. So $\Xi(2030)$, with main decay mode $\Sigma\bar{K}$, reported as a 3.5-standard-deviation effect, is not tabulated. See the Baryon Data Card Listings for the other states.

m. See note on $\Delta(1236)$ in the Baryon Data Card Listings. Values of mass and width are dependent upon resonance shape used to fit the data. The pole position appears to be much less dependent upon the parametrization used.

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

PHYSICAL AND NUMERICAL CONSTANTS*

PHYSICAL CONSTANTS

$N = 6.022169(40)\times10^{23}\ \text{mole}^{-1}$ (based on $A_{C^{12}} = 12$)

$c = 2.9979250(10)\times10^{10}\ \text{cm sec}^{-1}$

$e = 4.803250(21)\times10^{-10}\ \text{esu} = 1.6021917(70)\times10^{-19}\ \text{coulomb}$

$1\ \text{MeV} = 1.6021917(70)\times10^{-6}\ \text{erg}$

$\hbar = 6.582183(22)\times10^{-22}\ \text{MeV sec} = 1.0545919(80)\times10^{-27}\ \text{erg sec}$

$\hbar c = 1.9732891(66)\times10^{-11}\ \text{MeV cm} = 197.32891(66)\ \text{MeV fermi}$

$\quad = 0.6240088(21)\ \text{GeV mb}^{1/2}$

$\alpha = e^2/\hbar c = 1/137.03602(21)$

$k_{\text{Boltzmann}} = 1.380622(59)\times10^{-16}\ \text{erg K}^{-1}$

$\quad = 8.61708(37)\times10^{-11}\ \text{MeV K}^{-1} = 1\ \text{eV}/11604.85(49)\text{K}$

$m_e = 0.5110041(16)\ \text{MeV} = 9.109558(54)\times10^{-31}\ \text{kg}$

$m_p = 938.2592(52)\ \text{MeV} = 1836.109(11)\ m_e = 6.72211(63) m_{\pi^\pm}$

$\quad = 1.00727661(8) m_1$ (where $m_1 = 1\ \text{amu} = \frac{1}{12} m_{C^{12}} = 931.4812(52)\ \text{MeV}$)

$m_d = 1875.587(10)\ \text{MeV}$

$r_e = e^2/m_e c^2 = 2.817939(13)\ \text{fermi}$ ($1\ \text{fermi} = 10^{-13}\ \text{cm}$)

$\lambda\!\!\!^{-}_e = \hbar/m_e c = r_e \alpha^{-1} = 3.861592(12)\times10^{-11}\ \text{cm}$

$a_{\infty\ \text{Bohr}} = \hbar^2/m_e e^2 = r_e \alpha^{-2} = 0.52917715(81)\ \text{A}$ ($1\text{A} = 10^{-8}\ \text{cm}$)

$\sigma_{\text{Thomson}} = \frac{8}{3}\pi r_e^2 = 0.6652453(61)\times10^{-24}\ \text{cm}^2 = 0.6652453(61)\ \text{barns}$

$\mu_{\text{Bohr}} = e\hbar/2m_e c = 0.5788381(18)\times10^{-14}\ \text{MeV gauss}^{-1}$

$\mu_{\text{nucleon}} = e\hbar/2m_p c = 3.152526(21)\times10^{-18}\ \text{MeV gauss}^{-1}$

$\frac{1}{2}\omega^e_{\text{cyclotron}} = e/2m_e c = 8.794014(27)\times10^{6}\ \text{rad sec}^{-1}\ \text{gauss}^{-1}$

$\frac{1}{2}\omega^p_{\text{cyclotron}} = e/2m_p c = 4.789484(27)\times10^{3}\ \text{rad sec}^{-1}\ \text{gauss}^{-1}$

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

$$\frac{v}{c}\Big)_{\text{rms}} = \frac{ze^2}{n\hbar c}\,;\ E_n = \frac{\mu}{2}v^2 = \frac{\mu z^2 e^4}{2(n\hbar)^2}\,;\ a_n = \frac{n^2\hbar^2}{\mu z e^2}$$

$R_\infty = m_e e^4/2\hbar^2 = m_e c^2\alpha^2/2 = 13.605826(45)\ \text{eV}$ (Rydberg)

$pc = 0.3\ H\rho$(MeV, kilogauss, cm); 0.3 (which is $10^{-11}c$) enters because there are ≈ 300 "volts"/esu volt.

1 year (sidereal) $= 365.256$ days $= 3.1558\times10^{7}$ sec ($\approx \pi\times10^{7}$ sec)

density of dry air $= 1.205\ \text{mg cm}^{-3}$ (at 20 °C, 760 mm)

acceleration by gravity $= 980.62\ \text{cm sec}^{-2}$ (sea level, 45°)

gravitational constant $= 6.6732(31)\times10^{-8}\ \text{cm}^3\,\text{g}^{-1}\,\text{sec}^{-2}$

1 calorie (thermochemical) = 4.184 joules

1 atmosphere $= 1033.2275\ \text{g cm}^{-2}$

1 eV per particle $= 11604.85(49)\,°\text{K}$ (from $E = kT$)

NUMERICAL CONSTANTS

$\pi = 3.1415927$

$e = 2.7182818$

$\ln 2 = 0.6931472$

$\log_{10} 2 = 0.3010300$

$1\ \text{rad} = 57.2957795\ \text{deg}$

$1/e = 0.3678794$

$\ln 10 = 2.3025851$

$\log_{10} e = 0.4342945$

$\sqrt{\pi} = 1.7724539$

$\sqrt{2} = 1.4142136$

$\sqrt{3} = 1.7320508$

$\sqrt{10} = 3.1622777$

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*Compiled by Stanley J. Brodsky, based mainly on the adjustment of the fundamental physical constants by B. N. Taylor, W. H. Parker, and D. N. Langenberg, Rev. Mod. Phys. 41, 375 (1969). The figures in parentheses correspond to the 1 standard deviation uncertainty in the last digits of the main number.

CLEBSCH-GORDAN COEFFICIENTS AND SPHERICAL HARMONICS

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

Notation:

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

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

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

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

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

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

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

1/2 × 1/2

	1 +1
+1/2 +1/2	1

	1 0	0 0
+1/2 -1/2	1/2	1/2
-1/2 +1/2	1/2	-1/2

	1 -1
-1/2 -1/2	1

1 × 1/2

	3/2 +3/2
+1 +1/2	1

	3/2 +1/2	1/2 +1/2
+1 -1/2	1/3	2/3
0 +1/2	2/3	-1/3

	3/2 -1/2	1/2 -1/2
0 -1/2	2/3	1/3
-1 +1/2	1/3	-2/3

	3/2 -3/2
-1 -1/2	1

2 × 1/2

	5/2 +5/2
+2 1/2	1

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

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

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

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

	5/2 -5/2
-2 -1/2	1

3/2 × 1/2

	2 +2
+3/2 +1/2	1

	2 +1	1 +1
+3/2 -1/2	1/4	3/4
+1/2 +1/2	3/4	-1/4

	2 0	1 0
+1/2 -1/2	1/2	1/2
-1/2 +1/2	1/2	-1/2

	2 -1	1 -1
-1/2 -1/2	3/4	1/4
-3/2 +1/2	1/4	-3/4

	2 -2
-3/2 -1/2	1

2 × 1

	3 +3
+2 +1	1

	3 +2	2 +2
+2 0	1/3	2/3
+1 +1	2/3	-1/3

	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

	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

	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

	3 -2	2 -2
-1 -1	2/3	1/3
-2 0	1/3	-2/3

	3 -3
-2 -1	1

1 × 1

	2 +2
+1 +1	1

	2 +1	1 +1
+1 0	1/2	1/2
0 +1	1/2	-1/2

	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

	2 -1	1 -1
0 -1	1/2	1/2
-1 0	1/2	-1/2

	2 -2
-1 -1	1

3/2 × 1

	5/2 +5/2
+3/2 +1	1

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

	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

	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

	5/2 -3/2	3/2 -3/2
-1/2 -1	3/5	2/5
-3/2 0	2/5	-3/5

	5/2 -5/2
-3/2 -1	1

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

SU(3) CONVENTIONS

for Isoscalar Factor Table on next page

Since January 1970 we have used the convention that the first particle shall be a baryon, the second a meson (R. Levi Setti, Proceedings of Lund Conference, 1969, p. 339 and Table II). Note, for comparison, that the de Swart table of 8×8 is merely labeled with symbols like ($I_1 = 1/2$, $Y_1 = 1$, $I_2 = 1$, $Y_2 = 0$), which can be read either as (Nπ) or (KΣ). Since there are no decuplet mesons, however, his 8×10 table is unambiguous; it must be read with the meson first.

The de Swart convention violates the other convention that the N,Nπ coupling shall be D + F (as opposed to -D + F). To get D + F one must use the first line of the "N" table, which reads. . . $3\sqrt{5}/10\,|8_D\rangle + 1/2\,|8_F\rangle$ as opposed to. . . $-3\sqrt{5}/10\,|8_D\rangle + 1/2\,|8_F\rangle$. The first line must then be labeled Nπ rather than KΣ, i.e., with the baryon first.

Levi Setti further advocates the convention of writing the baryon first for SU(2) as well as SU(3). For example, the sign of the amplitudes as plotted on his and our Argand plots comes from using our SU(2) Clebsch-Gordan coefficients (Condon Shortley notation) and writing the baryon first. To make it easier to abide by this universal convention we have changed de Swart's 8×10 (SU(3) table to 10×8, with the help of his Eq. (14.3):

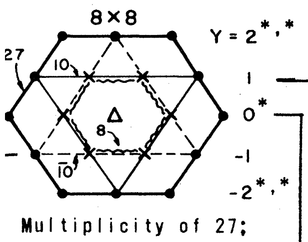
$$\langle \mu_1 \mu_2 | \mu\rangle = \xi_1 (-1)^{I_1+I_2-I} \langle \mu_2 \mu_1 | \mu\rangle .$$

SU(3) ISOSCALAR FACTORS

Adapted from J. J. de Swart, Rev. Mod. Phys. 35, 916 (1963)
(See note on previous page concerning conventions)

$\{8\} \otimes \{8\} = \{27\} \oplus \{10\} \oplus \{10^*\} \oplus \{8\}_1 \oplus \{8\}_2 \oplus \{1\}$.

* Five single-coefficient tables are omitted. The one involving a $\{10^*\}$ has a negative coefficient, i.e. $(NK|10^*) = -1$. The others, involving $\{27\}$ and $\{10\}$, are all +1.



Multiplicity of 27;
● = 1, × = 2, Δ = 3

$Y = 1 \quad I = 1/2$ N

	27	8_D	8_F	10^*
$\xi_1\rightarrow$	+	+	−	−
$N\pi$	$\sqrt{5}/10$	$3\sqrt{5}/10$	$1/2$	$-1/2$
ΣK	$-\sqrt{5}/10$	$-3\sqrt{5}/10$	$1/2$	$-1/2$
$N\eta$	$3\sqrt{5}/10$	$-\sqrt{5}/10$	$1/2$	$1/2$
ΛK	$3\sqrt{5}/10$	$-\sqrt{5}/10$	$-1/2$	$-1/2$

$Y = 1 \quad I = 3/2$ Δ

	27	10
$\xi_1\rightarrow$	+	−
$N\pi$	$\sqrt{2}/2$	$-\sqrt{2}/2$
ΣK	$\sqrt{2}/2$	$\sqrt{2}/2$

$Y = 0 \quad I = 0$ Λ

	27	8_D	1	8_F
$\xi_1\rightarrow$	+	+	+	−
$N\bar{K}$	$\sqrt{15}/10$	$\sqrt{10}/10$	$1/2$	$\sqrt{2}/2$
ΞK	$-\sqrt{15}/10$	$-\sqrt{10}/10$	$-1/2$	$\sqrt{2}/2$
$\Sigma\pi$	$-\sqrt{10}/20$	$-\sqrt{15}/5$	$\sqrt{6}/4$	0
$\Lambda\eta$	$3\sqrt{30}/20$	$-\sqrt{5}/5$	$-\sqrt{2}/4$	0

$Y = 0 \quad I = 1$ Σ

	27	8_D	8_F	10	10^*
$\xi_1\rightarrow$	+	+	−	−	−
$N\bar{K}$	$\sqrt{5}/5$	$-\sqrt{30}/10$	$\sqrt{6}/6$	$-\sqrt{6}/6$	$\sqrt{6}/6$
ΞK	$\sqrt{5}/5$	$-\sqrt{30}/10$	$-\sqrt{6}/6$	$\sqrt{6}/6$	$-\sqrt{6}/6$
$\Sigma\pi$	0	0	$\sqrt{6}/3$	$\sqrt{6}/6$	$-\sqrt{6}/6$
$\Sigma\eta$	$\sqrt{30}/10$	$\sqrt{5}/5$	0	$1/2$	$1/2$
$\Lambda\pi$	$\sqrt{30}/10$	$\sqrt{5}/5$	0	$-1/2$	$-1/2$

$Y = -1 \quad I = 1/2$ Ξ

	27	8_D	8_F	10
$\xi_1\rightarrow$	+	+	−	−
$\Xi\pi$	$-\sqrt{5}/10$	$-3\sqrt{5}/10$	$1/2$	$1/2$
$\Sigma\bar{K}$	$\sqrt{5}/10$	$3\sqrt{5}/10$	$1/2$	$1/2$
$\Xi\eta$	$3\sqrt{5}/10$	$-\sqrt{5}/10$	$-1/2$	$1/2$
$\Lambda\bar{K}$	$3\sqrt{5}/10$	$-\sqrt{5}/10$	$1/2$	$-1/2$

$Y = -1 \quad I = 3/2$

	27	10^*
$\xi_1\rightarrow$	+	−
$\Xi\pi$	$\sqrt{2}/2$	$-\sqrt{2}/2$
$\Sigma\bar{K}$	$\sqrt{2}/2$	$\sqrt{2}/2$

The phase factor $\xi_1 = \pm 1$, from de Swart's Table I, enters in his symmetry formula (14. 3):

$$\langle\mu_1\mu_2|\mu\rangle = \xi_1(-1)^{I_1+I_2-I}\langle\mu_2\mu_1|\mu\rangle .$$

This factor is irrelevant if you are doing your own self-consistent calculations; it enters when you try to check someone else who chose $\mu_2 \otimes \mu_1$ instead of $\mu_1 \otimes \mu_2$.

$\{10\} \otimes \{8\} = \{35\} \oplus \{27\} \oplus \{10\} \oplus \{8\}$.

* Four single coefficient tables are omitted; only the $\{27\}$ is -1; the three with $\{35\}$ are +1.

$Y = 1 \quad I = 1/2$ N

	27	8
$\xi_1\rightarrow$	−	+
$\Delta\pi$	$-\sqrt{5}/5$	$-2\sqrt{5}/5$
ΣK	$-2\sqrt{5}/5$	$\sqrt{5}/5$

$Y = 1 \quad I = 3/2$ Δ

	35	27	10
$\xi_1\rightarrow$	+	−	−
$\Delta\pi$	$1/4$	$-\sqrt{5}/4$	$\sqrt{10}/4$
$\Delta\eta$	$\sqrt{5}/4$	$3/4$	$\sqrt{2}/4$
ΣK	$\sqrt{10}/4$	$-\sqrt{2}/4$	$-1/2$

$Y = 0 \quad I = 0$ Λ

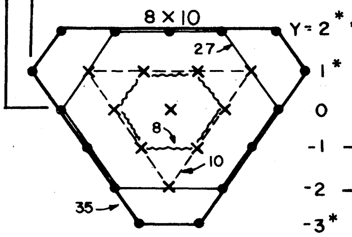
	27	8
$\xi_1\rightarrow$	−	+
$\Sigma\pi$	$-\sqrt{10}/5$	$-\sqrt{15}/5$
ΞK	$-\sqrt{15}/5$	$\sqrt{10}/5$

$Y = 0 \quad I = 1$ Σ

	35	27	10	8
$\xi_1\rightarrow$	+	−	−	+
$\Sigma\pi$	$\sqrt{3}/6$	$-3\sqrt{5}/10$	$\sqrt{3}/3$	$-\sqrt{30}/15$
$\Sigma\eta$	$\sqrt{2}/2$	$\sqrt{30}/10$	0	$-\sqrt{5}/5$
ΞK	$\sqrt{3}/3$	$-\sqrt{5}/5$	$-\sqrt{3}/3$	$\sqrt{30}/15$
$\Delta\bar{K}$	$\sqrt{3}/6$	$\sqrt{5}/10$	$\sqrt{3}/3$	$2\sqrt{30}/15$

$Y = 0 \quad I = 2$

	35	27
$\xi_1\rightarrow$	+	−
$\Sigma\pi$	$\sqrt{3}/2$	$-1/2$
$\Delta\bar{K}$	$1/2$	$\sqrt{3}/2$



Multiplicity of 35;
● = 1, × = 2

$Y = -1 \quad I = 1/2$ Ξ

	35	27	10	8
$\xi_1\rightarrow$	+	−	−	+
$\Xi\pi$	$1/4$	$-7\sqrt{5}/20$	$\sqrt{2}/4$	$-\sqrt{5}/5$
$\Xi\eta$	$3/4$	$3\sqrt{5}/20$	$-\sqrt{2}/4$	$-\sqrt{5}/5$
ΩK	$\sqrt{2}/4$	$-3\sqrt{10}/20$	$-1/2$	$\sqrt{10}/5$
$\Sigma\bar{K}$	$1/2$	$\sqrt{5}/10$	$\sqrt{2}/2$	$\sqrt{5}/5$

$Y = -1 \quad I = 3/2$

	35	27
$\xi_1\rightarrow$	+	−
$\Xi\pi$	$\sqrt{2}/2$	$-\sqrt{2}/2$
$\Sigma\bar{K}$	$\sqrt{2}/2$	$\sqrt{2}/2$

$Y = -2 \quad I = 0$ Ω^-

	35	10
$\xi_1\rightarrow$	+	−
$\Omega\eta$	$\sqrt{2}/2$	$-\sqrt{2}/2$
$\Xi\bar{K}$	$\sqrt{2}/2$	$\sqrt{2}/2$

$Y = -2 \quad I = 1$

	35	27
$\xi_1\rightarrow$	+	−
$\Omega\pi$	$1/2$	$-\sqrt{3}/2$
$\Xi\bar{K}$	$\sqrt{3}/2$	$1/2$

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 (MEV/C)	-----C.M. ENERGY------ (MEV)				-MOMENTUM IN C.M.-- (MEV/C)			
	γp ep	πp	Kp	pp	γp ep	πp	Kp	pp
0	939	1078	1432	1877	0	0	0	0
20	958	1079	1432	1877	20	17	13	10
40	977	1083	1433	1877	38	35	26	20
60	996	1089	1434	1877	56	52	39	30
80	1015	1096	1436	1878	74	68	52	40
		T(PI) = PBEAM - 59 MEV						
100	1033	1105	1439	1879	91	85	65	50
120	1051	1116	1441	1880	107	101	78	60
140	1069	1127	1445	1882	123	117	91	70
160	1087	1139	1449	1883	138	132	104	80
180	1104	1152	1453	1885	153	147	116	90
		T(PI) = PBEAM - 92 MEV						
200	1121	1165	1457	1887	167	161	129	99
220	1137	1178	1462	1889	182	175	141	109
240	1154	1192	1468	1892	195	189	153	119
260	1170	1206	1474	1894	209	202	166	129
280	1186	1219	1480	1897	222	215	178	138
		T(PI) = PBEAM - 107 MEV						
300	1201	1233	1486	1900	234	228	189	148
320	1217	1247	1493	1903	247	241	201	158
340	1232	1261	1500	1906	259	253	213	167
360	1247	1274	1507	1910	271	265	224	177
380	1262	1288	1514	1913	282	277	235	186
		T(PI) = PBEAM - 115 MEV						
400	1277	1302	1522	1917	294	288	247	196
420	1292	1315	1530	1921	305	300	258	205
440	1306	1329	1538	1925	316	311	268	214
460	1320	1342	1546	1929	327	322	279	224
480	1335	1356	1554	1933	337	332	290	233
		T(PI) = PBEAM - 120 MEV						
500	1349	1369	1563	1938	348	343	300	242
520	1362	1382	1572	1943	358	353	310	251
540	1376	1395	1580	1947	368	363	321	260
560	1390	1408	1589	1952	378	373	331	269
580	1403	1421	1598	1957	388	383	341	278
		T(PI) = PBEAM - 123 MEV						
600	1416	1434	1607	1962	397	393	350	287
620	1430	1446	1616	1967	407	402	360	296
640	1443	1459	1625	1973	416	412	370	304
660	1456	1472	1634	1978	425	421	379	313
680	1468	1484	1644	1984	434	430	388	322
		T(PI) = PBEAM - 125 MEV						
700	1481	1496	1653	1989	443	439	397	330
720	1494	1509	1662	1995	452	448	406	339
740	1506	1521	1671	2001	461	457	415	347
760	1519	1533	1681	2007	470	465	424	355
780	1531	1545	1690	2013	478	474	433	364
		T(PI) = PBEAM - 127 MEV						
800	1543	1557	1699	2019	486	482	442	372
820	1555	1569	1709	2025	495	490	450	380
840	1567	1580	1718	2031	503	499	459	388
860	1579	1592	1728	2037	511	507	467	396
880	1591	1604	1737	2043	519	515	475	404
		T(PI) = PBEAM - 129 MEV						
900	1603	1615	1747	2049	527	523	483	412
920	1615	1627	1756	2056	535	531	492	420
940	1626	1638	1765	2062	542	538	500	428
960	1638	1649	1775	2069	550	546	508	435
980	1649	1661	1784	2075	558	554	515	443
		T(PI) = PBEAM - 130 MEV						
1000	1660	1672	1794	2082	565	561	523	451
1020	1672	1683	1803	2088	573	569	531	458
1040	1683	1694	1812	2095	580	576	538	466
1060	1694	1705	1822	2102	587	583	546	473
1080	1705	1716	1831	2108	594	591	553	481
		T(PI) = PBEAM - 131 MEV						
1100	1716	1726	1840	2115	601	598	561	488
1120	1727	1737	1850	2122	609	605	568	495
1140	1738	1748	1859	2129	616	612	575	502
1160	1748	1758	1868	2135	622	619	583	510
1180	1759	1769	1877	2142	629	626	590	517
		T(PI) = PBEAM - 131 MEV						
1200	1770	1780	1887	2149	636	633	597	524
1220	1780	1790	1896	2156	643	639	604	531
1240	1791	1800	1905	2163	650	646	611	538
1260	1801	1811	1914	2170	656	653	618	545
1280	1812	1821	1923	2177	663	660	624	552
		T(PI) = PBEAM - 132 MEV						
1300	1822	1831	1932	2184	669	666	631	559
1320	1832	1841	1941	2191	676	673	638	565
1340	1843	1851	1950	2198	682	679	645	572
1360	1853	1862	1959	2205	689	685	651	579
1380	1863	1872	1968	2212	695	692	658	585
		T(PI) = PBEAM - 133 MEV						
1400	1873	1881	1977	2219	701	698	664	592
1420	1883	1891	1986	2226	708	704	671	599
1440	1893	1901	1995	2233	714	711	677	605
1460	1903	1911	2004	2240	720	717	684	612
1480	1912	1921	2013	2247	726	723	690	618
		T(PI) = PBEAM - 133 MEV						

PBEAM (MEV/C)	-----C.M. ENERGY------ (MEV)				-MOMENTUM IN C.M.-- (MEV/C)			
	γp ep	πp	Kp	pp	γp ep	πp	Kp	pp
1500	1922	1930	2022	2254	732	729	696	624
1520	1932	1940	2031	2261	738	735	702	631
1540	1942	1950	2039	2268	744	741	709	637
1560	1951	1959	2048	2275	750	747	715	643
1580	1961	1969	2057	2282	756	753	721	650
		T(PI) = PBEAM - 133 MEV						
1600	1970	1978	2065	2289	762	759	727	656
1620	1980	1988	2074	2296	768	765	733	662
1640	1989	1997	2083	2304	773	770	739	668
1660	1999	2006	2091	2311	779	776	745	674
1680	2008	2016	2100	2318	785	782	751	680
		T(PI) = PBEAM - 134 MEV						
1700	2018	2025	2109	2325	791	788	756	686
1720	2027	2034	2117	2332	796	793	762	692
1740	2036	2043	2126	2339	802	799	768	698
1760	2045	2053	2134	2346	807	805	774	704
1780	2054	2062	2143	2353	813	810	779	710
		T(PI) = PBEAM - 134 MEV						
1800	2064	2071	2151	2360	818	816	785	716
1820	2073	2080	2159	2367	824	821	791	721
1840	2082	2089	2168	2374	829	827	796	727
1860	2091	2098	2176	2381	835	832	802	733
1880	2100	2107	2184	2388	840	837	808	739
		T(PI) = PBEAM - 134 MEV						
1900	2108	2115	2193	2395	845	843	813	744
1920	2117	2124	2201	2402	851	848	818	750
1940	2126	2133	2209	2409	856	853	824	756
1960	2135	2142	2217	2416	861	859	829	761
1980	2144	2150	2226	2423	867	864	835	767
		T(PI) = PBEAM - 135 MEV						
2000	2153	2159	2234	2430	872	869	840	772
2020	2161	2168	2242	2437	877	874	845	778
2040	2170	2176	2250	2444	882	879	851	783
2060	2179	2185	2258	2451	887	885	856	789
2080	2187	2194	2266	2458	892	890	861	794
		T(PI) = PBEAM - 135 MEV						
2100	2196	2202	2274	2465	897	895	866	799
2120	2204	2211	2282	2472	902	900	872	805
2140	2213	2219	2290	2479	907	905	877	810
2160	2221	2227	2298	2486	912	910	882	815
2180	2230	2236	2306	2493	917	915	887	821
		T(PI) = PBEAM - 135 MEV						
2200	2238	2244	2314	2500	922	920	892	826
2220	2246	2253	2322	2507	927	925	897	831
2240	2255	2261	2330	2514	932	930	902	836
2260	2263	2269	2338	2520	937	934	907	841
2280	2271	2277	2346	2527	942	939	912	846
		T(PI) = PBEAM - 135 MEV						
2300	2280	2286	2353	2534	947	944	917	852
2320	2288	2294	2361	2541	951	949	922	857
2340	2296	2302	2369	2548	956	954	927	862
2360	2304	2310	2377	2555	961	959	932	867
2380	2312	2318	2384	2561	966	963	937	872
		T(PI) = PBEAM - 135 MEV						
2400	2320	2326	2392	2568	970	968	941	877
2420	2328	2334	2400	2575	975	973	946	882
2440	2336	2342	2407	2582	980	977	951	887
2460	2344	2350	2415	2589	984	982	956	892
2480	2352	2358	2423	2595	989	987	960	897
		T(PI) = PBEAM - 136 MEV						
2500	2360	2366	2430	2602	994	991	965	901
2520	2368	2374	2438	2609	998	996	970	906
2540	2376	2382	2445	2616	1003	1001	975	911
2560	2384	2390	2453	2622	1007	1005	979	916
2580	2392	2398	2460	2629	1012	1010	984	921
		T(PI) = PBEAM - 136 MEV						
2600	2400	2405	2468	2636	1017	1014	988	926
2620	2408	2413	2475	2643	1021	1019	993	930
2640	2415	2421	2483	2649	1025	1023	998	935
2660	2423	2429	2490	2656	1030	1028	1002	940
2680	2431	2436	2498	2663	1034	1032	1007	944
		T(PI) = PBEAM - 136 MEV						
2700	2439	2444	2505	2669	1039	1037	1011	949
2720	2446	2452	2512	2676	1043	1041	1016	954
2740	2454	2459	2520	2682	1048	1045	1020	958
2760	2462	2467	2527	2689	1052	1050	1025	963
2780	2469	2474	2534	2696	1056	1054	1029	968
		T(PI) = PBEAM - 136 MEV						
2800	2477	2482	2542	2702	1061	1058	1034	972
2820	2484	2490	2549	2709	1065	1063	1038	977
2840	2492	2497	2556	2715	1069	1067	1042	981
2860	2499	2505	2563	2722	1074	1071	1047	986
2880	2507	2512	2570	2728	1078	1076	1051	990
		T(PI) = PBEAM - 136 MEV						
2900	2514	2520	2578	2735	1082	1080	1056	995
2920	2522	2527	2585	2742	1086	1084	1060	999
2940	2529	2534	2592	2748	1091	1088	1064	1004
2960	2537	2542	2599	2755	1095	1093	1069	1008
2980	2544	2549	2606	2761	1099	1097	1073	1013
		T(PI) = PBEAM - 136 MEV						

PBEAM (GEV/C)	---C.M. ENERGY--- (GEV)			-MOMENTUM IN C.M.- (GEV/C)		
	γp ep πp	Kp	pp	γp ep πp	Kp	pp
3.0	2.56	2.61	2.77	1.10	1.08	1.02
3.2	2.63	2.68	2.83	1.14	1.12	1.06
3.4	2.70	2.75	2.89	1.18	1.16	1.10
3.6	2.77	2.82	2.96	1.22	1.20	1.14
3.8	2.83	2.88	3.02	1.26	1.24	1.18
	T(PI) = PBEAM - .137 GEV					
4.0	2.90	2.95	3.08	1.29	1.27	1.22
4.2	2.96	3.01	3.14	1.33	1.31	1.26
4.4	3.03	3.07	3.19	1.36	1.34	1.29
4.6	3.09	3.13	3.25	1.40	1.38	1.33
4.8	3.15	3.19	3.31	1.43	1.41	1.36
	T(PI) = PBEAM - .138 GEV					
5.0	3.21	3.25	3.36	1.46	1.44	1.40
5.2	3.27	3.31	3.42	1.49	1.48	1.43
5.4	3.32	3.36	3.47	1.53	1.51	1.46
5.6	3.38	3.42	3.52	1.56	1.54	1.49
5.8	3.43	3.47	3.58	1.59	1.57	1.52
	T(PI) = PBEAM - .138 GEV					
6.0	3.49	3.52	3.63	1.61	1.60	1.55
6.2	3.54	3.58	3.68	1.64	1.63	1.58
6.4	3.59	3.63	3.73	1.67	1.65	1.61
6.6	3.65	3.68	3.78	1.70	1.68	1.64
6.8	3.70	3.73	3.83	1.73	1.71	1.67
	T(PI) = PBEAM - .138 GEV					
7.0	3.75	3.78	3.87	1.75	1.74	1.70
7.2	3.80	3.83	3.92	1.78	1.76	1.72
7.4	3.85	3.88	3.97	1.81	1.79	1.75
7.6	3.89	3.93	4.02	1.83	1.82	1.78
7.8	3.94	3.97	4.06	1.86	1.84	1.80
	T(PI) = PBEAM - .138 GEV					
8.0	3.99	4.02	4.11	1.88	1.87	1.83
8.2	4.04	4.07	4.15	1.91	1.89	1.85
8.4	4.08	4.11	4.20	1.93	1.92	1.88
8.6	4.13	4.16	4.24	1.95	1.94	1.90
8.8	4.17	4.20	4.29	1.98	1.96	1.93
	T(PI) = PBEAM - .138 GEV					
9.0	4.22	4.25	4.33	2.00	1.99	1.95
9.2	4.26	4.29	4.37	2.03	2.01	1.97
9.4	4.31	4.33	4.41	2.05	2.03	2.00
9.6	4.35	4.38	4.46	2.07	2.06	2.02
9.8	4.39	4.42	4.50	2.09	2.08	2.04
	T(PI) = PBEAM - .139 GEV					
10.0	4.43	4.46	4.54	2.12	2.10	2.07
10.5	4.54	4.57	4.64	2.17	2.16	2.12
11.0	4.64	4.67	4.74	2.22	2.21	2.18
11.5	4.74	4.77	4.84	2.28	2.26	2.23
12.0	4.84	4.86	4.93	2.33	2.31	2.28
	T(PI) = PBEAM - .139 GEV					
12.5	4.94	4.96	5.03	2.38	2.36	2.33
13.0	5.03	5.05	5.12	2.43	2.41	2.38
13.5	5.12	5.15	5.21	2.47	2.46	2.43
14.0	5.21	5.24	5.30	2.52	2.51	2.48
14.5	5.30	5.32	5.39	2.57	2.56	2.53
	T(PI) = PBEAM - .139 GEV					
15.0	5.39	5.41	5.47	2.61	2.60	2.57
16.0	5.56	5.58	5.64	2.70	2.69	2.66
17.0	5.73	5.75	5.81	2.78	2.77	2.75
18.0	5.89	5.91	5.97	2.87	2.86	2.83
19.0	6.05	6.07	6.12	2.95	2.94	2.91
	T(PI) = PBEAM - .139 GEV					
20.0	6.20	6.22	6.27	3.03	3.02	2.99
22.0	6.49	6.51	6.56	3.18	3.17	3.14
24.0	6.78	6.79	6.84	3.32	3.31	3.29
26.0	7.05	7.07	7.11	3.46	3.45	3.43
28.0	7.31	7.33	7.37	3.59	3.59	3.56
	T(PI) = PBEAM - .139 GEV					
30.0	7.56	7.58	7.62	3.72	3.71	3.69
32.0	7.81	7.82	7.86	3.85	3.84	3.82
34.0	8.04	8.06	8.10	3.97	3.96	3.94
36.0	8.27	8.29	8.33	4.08	4.08	4.06
38.0	8.50	8.51	8.55	4.20	4.19	4.17
	T(PI) = PBEAM - .139 GEV					
40.0	8.72	8.73	8.77	4.31	4.30	4.28
42.0	8.93	8.94	8.98	4.41	4.41	4.39
44.0	9.14	9.15	9.18	4.52	4.51	4.50
46.0	9.34	9.35	9.39	4.62	4.62	4.60
48.0	9.54	9.55	9.58	4.72	4.72	4.70
	T(PI) = PBEAM - .139 GEV					
50.0	9.73	9.74	9.78	4.82	4.81	4.80
60.0	10.65	10.66	10.69	5.28	5.28	5.26
70.0	11.50	11.51	11.54	5.71	5.71	5.69
80.0	12.29	12.30	12.32	6.11	6.10	6.09
90.0	13.03	13.04	13.06	6.48	6.48	6.46
	T(PI) = PBEAM - .139 GEV					
100.0	13.73	13.74	13.76	6.83	6.83	6.82
200.0	19.40	19.40	19.42	9.67	9.67	9.66
500.0	30.65	30.65	30.66	15.31	15.31	15.30
1000.0	43.33	43.33	43.34	21.65	21.65	21.65
1500.0	53.06	53.06	53.07	26.52	26.52	26.52
	T(PI) = PBEAM - .140 GEV					

SPECIAL RELATIVITY, PHASE SPACE, AND CROSS SECTIONS

Notation. 4-vector in c.m. $p = (w, \vec{p})$; in lab $P = (W, \vec{P})$, $T = W - m$.
Solid-angle element $d\omega = 2\pi d \cos\theta$; $d\Omega = 2\pi d \cos\Theta$.
$p^2 = w^2 - \vec{p}^2 = m^2$ is an invariant. Cross section σ is invariant.

Lorentz Transformation

$$\begin{pmatrix} w \\ p_x \\ p_y \\ p_z \end{pmatrix} = \begin{pmatrix} \bar{\gamma} & -\bar{\eta} & 0 & 0 \\ -\bar{\eta} & \bar{\gamma} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} W \\ P_x \\ P_y \\ P_z \end{pmatrix}$$

If θ and Θ are measured with respect to the transformation axis x,

$$\frac{p_\perp}{p_x} = \tan\theta = \frac{|\vec{P}|\sin\Theta}{-\bar{\eta}W + \bar{\gamma}|\vec{P}|\cos\Theta} . \qquad (1)$$

If particle 1 is beam, 2 is target, then $(W_2, \vec{P}_2) = (m_2, \vec{0})$ and

$$\bar{\gamma} = (W_1 + m_2)/\sqrt{s},\ \bar{\eta} \equiv \bar{\gamma\beta} = |\vec{P}_1|/\sqrt{s},\ |\vec{p}_1| = |\vec{p}_2| = \bar{\eta}m_2 = |\vec{P}_1|m_2/\sqrt{s}. \qquad (2)$$

For $m_1 = m_2$, $\bar{\gamma}^2 = 1 + T_1/2m_1$.

General Lorentz Transformation [characterized by $\vec{\bar{\beta}}$, with $\bar{\gamma} = (1 - \vec{\bar{\beta}}^2)^{-1/2}$ and $\vec{\bar{\eta}} = \bar{\gamma}\vec{\bar{\beta}}$]: $w = \bar{\gamma}W - \vec{\bar{\eta}} \cdot \vec{P}$; $\vec{p} = \vec{P} - \vec{\bar{\eta}}\,\dfrac{W + w}{\bar{\gamma} + 1}$.

A Useful Transformation: Consider two 4-vectors $Q = (E, \vec{Q})$ and $q = (e, \vec{q})$. In the rest frame of Q $[Q' = (M, \vec{0})]$, q becomes $(q \rightarrow q')$

$$e' = Q \cdot q/M \quad \text{and} \quad \vec{q}' = \vec{q} - f\vec{Q},$$

where $Q^2 = M^2$ and $f = (e + e')/(E + M)$. These equations follow from example (b), p. 34 of Hagedorn.* They are particularly useful when Q is a sum of four-vectors that correspond to a resonant state.

Invariants. Notation: $1 + 2 \rightarrow 1' + 2'$.

$$s = (p_1 + p_2)^2 = m_1^2 + m_2^2 + 2(w_1 w_2 - \vec{p}_1 \cdot \vec{p}_2) , \qquad (3)$$

$$t = (p_i' - p_i)^2 = m_i^2 + m_i'^2 - 2(w_i w_i' - \vec{p}_i \cdot \vec{p}_i'), \quad (i = 1, 2), \qquad (4)$$

$$u = (p_1' - p_2)^2 = (p_2' - p_1)^2 \qquad [\text{use (6), below}]. \qquad (5)$$

General relation: $s + t + u = m_1^2 + m_1'^2 + m_2^2 + m_2'^2$. (6)

In lab system $P_2 = (m_2, \vec{0})$, and writing $W = m + T$,

$$s = m_1^2 + m_2^2 + 2W_1 m_2 = (m_1 + m_2)^2 + 2\,T_1 m_2 , \qquad (3,\text{lab})$$

$$t = m_2^2 + m_2'^2 - 2W_2' m_2 = (m_2 - m_2')^2 - 2\,T_2' m_2 . \qquad (4,\text{lab})$$

In c.m. system $dt = +2|\vec{p}_i|\ |\vec{p}_i'|\ d\cos\theta$. (4,cm)

For elastic scattering $(m_1 = m_1',\ m_2 = m_2')$, (4) and (5) in c.m. become

$$t = -2\vec{p}^2 (1 - \cos\theta) = -4\vec{p}^2 \sin^2\theta/2 , \qquad (4,\text{el})$$

$$u = (m_1^2 - m_2^2)^2/s - 2\vec{p}^2(1 + \cos\theta) = (m_1^2 - m_2^2)^2/s - 4\vec{p}^2\cos^2\theta/2. \qquad (5,\text{el})$$

For elastic scattering, using (4,lab), (4,el), and (2),

$$T_2' = \frac{2\vec{P}_1^2 m_2}{s} \sin^2\left(\frac{\theta}{2}\right) \text{(useful for calculating } \delta\text{-ray energies).} \qquad (7)$$

Two-Body States. Energies and momenta in c.m.

$$w_1 = \frac{s + m_1^2 - m_2^2}{2\sqrt{s}},\ \vec{p}_1^{\,2} = \vec{p}_2^{\,2} = \frac{1}{4s}\,[s - (m_1 + m_2)^2]\,[s - (m_1 - m_2)^2] . \qquad (8)$$

3- and 4-Body States. Let $m_{ij}^2 = (p_i + p_j)^2$, etc.; then

$$\sum_{i<j} m_{ij}^2 = \Sigma m_i^2 + m_{123}^2 = \text{const.}\ (i, j = 1, 2, 3)\ [\text{follows from (6)}] \qquad (9)$$

$$\left.\begin{aligned} &= 2\Sigma m_i^2 + m_{1234}^2 = \text{const.} \\ \sum_{i<j<k} m_{ijk}^2 &= \Sigma m_i^2 + 2m_{1234}^2 = \text{const.} \end{aligned}\right\} (i, j, k = 1, 2, 3, 4.) \qquad (10)$$

R_n, Invariant Volume in n-Body Momentum Space

A useful invariant is $\int d^4p\, \delta(p^2 - m^2) = \int \dfrac{d^3\vec{p}}{2w} = \int \dfrac{p^2 d|\vec{p}|d\omega}{2w} = \dfrac{1}{2}\int |\vec{p}|dw d\omega$.
$R_2 = \pi|\vec{p}_1|/\sqrt{s}$, $R_3 = \pi^2 \int dw_1 dw_2 = (\pi^2/4s)\int dm_{12}^2 dm_{23}^2$.

Recurrence Relation for Factoring R_n (see e.g., Hagedorn, p. 93*):

Write $N \rightarrow 1, 2, \cdots, k,\ k+1, \cdots, n \quad (R_n)$,

$$\text{as}\quad \left.\begin{array}{lll} N \rightarrow K, & k+1, \cdots, n & (R_{n-k+1}) \\ & \hookrightarrow 1, 2, \cdots, k & (R_k) \end{array}\right\} \left\{\begin{array}{l} \text{then} \\ R_n = \int d(m_K^2) R_k R_{n-k+1}, \end{array}\right.$$

$$\text{or as}\quad N \rightarrow K, L \quad \left.\begin{array}{ll} \hookrightarrow k+1, \cdots, n & (R_\ell) \\ \hookrightarrow 1, 2, \cdots, k & (R_k) \end{array}\right\} \left\{\begin{array}{l} \text{then} \\ R_n = \int d(m_K^2) d(m_L^2) R_k R_\ell \dfrac{\pi p_{(KL)}}{\sqrt{s}} \end{array}\right.$$

Cross Sections and Decay Rates†

For a system of n particles with overall four-momentum p and final momenta $q_1, \cdots, q_n$ $[q_i = (e_i, \vec{q}_i)]$, define Lorentz Invariant Phase Space

$$d\,\text{LIPS}(s; q_1, \cdots, q_n) = (2\pi)^4 \delta^4(p - \sum_i q_i) \frac{1}{(2\pi)^{3n}} \prod_{i=1}^{n} \frac{d^3\vec{q}_i}{2e_i} . \qquad (11)$$

Note that $R_n = (2\pi)^{3n-4} \int d\,\text{LIPS}$.

For $1 + 2 \rightarrow$ n particles or $1 \rightarrow$ n particles, in general $|i\rangle \rightarrow |f\rangle$,

$$\sigma_{if} = \frac{1}{4F} \int |T_{if}|^2\, d\,\text{LIPS}(s; q_1, \cdots, q_n) , \qquad (12)$$

or

$$\Gamma_{if} = \frac{1}{2m_1} \int |T_{if}|^2\, d\,\text{LIPS}(m_1^2; q_1, \cdots, q_n) , \qquad (13)$$

where T_{if} is an invariant matrix element. F is Møller's invariant flux factor, $F^2 = (p_1 \cdot p_2)^2 - p_1^2 p_2^2$. In every system where $\vec{p}_1$ and $\vec{p}_2$ are collinear, $F = w_1 w_2 |\vec{v}_1 - \vec{v}_2|$ $(\vec{v} = \vec{p}/w)$. If 1 is beam, 2, target $(\vec{p}_2 = 0)$, then $F = |\vec{P}_1|m_2 = |\vec{p}_1|\sqrt{s}$.

For elastic scattering in c.m., $\dfrac{d\,\text{LIPS}}{d\Omega} = \dfrac{1}{(4\pi)^2} \dfrac{|\vec{p}_1|}{\sqrt{s}}$, and (12) yields

$$\frac{d\sigma}{d\Omega} = \frac{|T|^2}{(8\pi)^2 s} \quad \text{or} \quad \frac{d\sigma}{dt} = \frac{|T|^2}{64\pi|\vec{p}_1|^2 s} . \qquad (14)$$

The normalization is such that the optical theorem reads

$$\text{Im}\, T|_{t=0} = 2|\vec{p}_1|\sqrt{s}\,\sigma_{\text{tot}} . \qquad (15)$$

The choice of Eq. (11) implies a particular normalization of any spinors that may occur in T.† The advantage of this normalization is that it greatly simplifies the structure of T 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.

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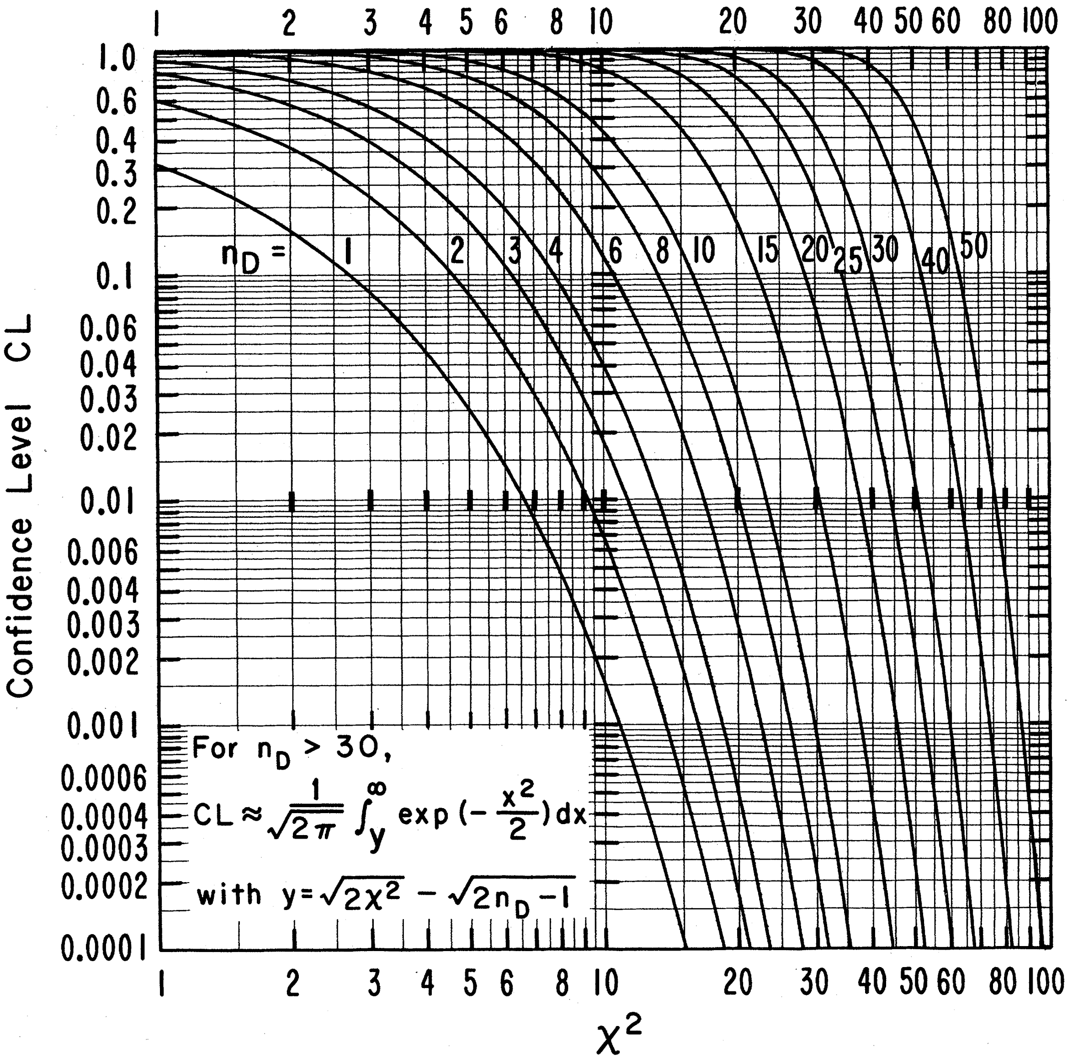
*R. Hagedorn, Relativistic Kinematics, W. A. Benjamin, New York, 1964.

†See, for example, Chaps. 1 and 2 of H. Pilkhuhn, The Interactions of Hadrons, John Wiley & Sons, New York, 1967.

CONFIDENCE LEVEL VS. χ^2 FOR n_D DEGREES OF FREEDOM



For $n_D > 30$,

$$CL \approx \frac{1}{\sqrt{2\pi}} \int_y^\infty \exp\left(-\frac{x^2}{2}\right) dx$$

with $y = \sqrt{2\chi^2} - \sqrt{2n_D - 1}$

For any n_D, $\langle \chi^2 \rangle = n_D$, $\delta(\chi^2) = \sqrt{2n_D}$. For large n_D, χ^2 becomes normally distributed about n_D. Thus in the notation of the box in the figure,

$$y_1 = (\chi^2 - n_D)/\sqrt{2n_D} \text{ has unit s.d.}$$

A better approximation, due to Fisher,* is that χ, not χ^2, is normally distributed, specifically

$$y_2 = \sqrt{2\chi^2} - \sqrt{2n_D - 1} \text{ has unit s.d.}$$

One sees then that y_1 underestimates small C.L.'s. Thus for n = 50 and $\chi^2 = 80$, $y_1 = 3.0$ and C.L. = 0.13% vs. $y_2 = 2.7$, C.L. = 0.35%.

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*R. A. Fisher, Statistical Methods for Research Workers, Oliver and Boyd, Edinburgh.

The Poisson distribution for x, when expected value is $\bar{x}$:

$$P(x, \bar{x}) = \bar{x}^x e^{-\bar{x}}/x!$$

Approximation for n! :

$$\sqrt{2\pi n}\,(n/e)^n < n! < \sqrt{2\pi n}\,(n/e)^n[1 + 1/(12n - 1)]$$

GAUSSIANLIKE DISTRIBUTIONS

The distribution

$$P_{2n+1}(x) = \frac{1}{2^n n!\,\sigma^{2n+2}}\, x^{2n+1} \exp\left[-\frac{x^2}{2\sigma^2}\right]$$

is normalized so that $\int_0^\infty P_{2n+1}(x)dx = 1$; the normalization is valid for n > -1 and not necessarily integral $((\frac{1}{2})! = \sqrt{\pi}/2)$. For n = -1/2 it reduces to the Gaussian distribution. Through a change of variables it yields the χ^2 distribution for n_D degrees of freedom:

$$P_{n_D}(\chi^2) = \frac{1}{2^{n_D/2}\left(\frac{n_D}{2} - 1\right)!}\,(\chi^2)^{n_D/2-1} \exp\left[-\chi^2/2\right].$$

Relation between standard deviation σ and mean deviation α:

$$2\sigma^2 = \pi\alpha^2;\ \sigma = 1.4826 \text{ probable error.}$$

Odds against exceeding one standard deviation = 2.15:1; two, 21:1; three, 370:1; four, 16,000:1; five, 1,700,000:1.

ATOMIC AND NUCLEAR PROPERTIES OF MATERIALS

Material	Z	A	Nominal[a] Cross Section σ barns		Nominal Collision Length $L_{Coll.}$[b]		Absorption Length[m, n] λ, cm	dE/dx[c] min.		Radiation Length L_{rad}[d]		Density ρ $g\ cm^{-3}$
					$g\ cm^{-2}$	cm		$\frac{MeV}{g/cm^2}$	$\frac{MeV}{cm}$	$g\ cm^{-2}$	cm	
H_2	1	1.01	0.063	WARNING: See notes a and b.	26.5	374^e		4.13	0.292^e	62.8	887^e	0.0708^e
D_2	1	2.01	0.100		33.4	202^e		2.07	0.342^e	126	764^e	0.165^e
He	2	4.00	0.16		42.0	336^e		1.94	0.243^e	93.1	745^e	0.125^e
Li	3	6.94	0.23		50.4	94.4		1.69	0.902	83.3	156	0.534
Be	4	9.01	0.28		55.0	29.8	39.5	1.60	2.96	66.0	35.7	1.848
C	6	12.01	0.33		60.4	f		1.78	f	43.3	f	$\approx 1.55^f$
N_2	7	14.01	0.36		63.6	78.7^e		1.81	1.46^e	38.6	47.8^e	0.808^e
Ne	10	20.18	0.465		72.1	60.1^e		1.73	2.08^e	29.1^i	$24.3^{e,i}$	$1.200^{e,k}$
Al	13	26.98	0.57		79.2	29.3	38.8	1.62	4.37	24.3	9.00	2.70
Fe	26	55.85	0.92		101.2	12.9	17.1	1.48	11.6	13.9	1.77	7.87
Cu	29	63.54	1.00		105.4	11.8	15.6	1.44	12.9	13.0	1.45	8.96
Sn	50	118.69	1.55		129.7	17.7		1.28	9.4	8.9	1.22	7.31
W	74	183.85	2.02		150.8	7.81		1.17	22.6	6.8	0.35	19.3
Pb	82	207.19	2.20		156.2	13.8	18.3	1.13	12.8	6.4	0.56	11.35
U	92	238.03	2.42		163.6	≈ 8.63		1.09	≈ 20.7	6.1	≈ 0.32	≈ 18.95
Air				WARNING: See notes a and b.	64.6	53610^g		1.81	0.0022^g	37.2	30870^g	0.001205^g
Freon (CF_3Br)					87.1	≈ 58		1.52	≈ 2.3	16.7	≈ 11	≈ 1.5
H_2 (bubble chamber, 27° K)					26.5	442^h		4.13	0.248^h	62.8	1050^h	$\approx 0.060^h$
H-Ne mixture (bubble chamber)[j]					67.3	96.1		1.83	1.28	29.8^i	42.6^i	0.70
H_2O					57.2	57.2		2.03	2.03	36.4	36.4	1.00
Ilford Emulsion					103.0	27.0		1.44	5.49	11.2	2.94	3.815
LiF					63.8	24.2		1.69	4.46	39.8	15.1	2.64
Mylar ($C_5H_4O_2$)					59.1	42.8		1.91	2.64	40.4	29.3	1.38
NaI					119.0	32.4		1.32	4.84	9.5	2.59	3.67
Polyethylene (CH_2)					51.0	≈ 55		2.09	≈ 1.92	45.3	≈ 49	≈ 0.92
Polystyrene (CH)[ℓ] [≈Scintillator]					54.9	≈ 52	68.5	2.03	≈ 2.13	44.3	≈ 42	≈ 1.05
Propane (C_3H_8, bubble chamber)					48.9	119		2.28	0.94	45.9	112	0.41

a. $\sigma = \sigma_{nominal} = \pi(\hbar/m_\pi c)^2 \times A^{2/3} = 62.8\ mb \times A^{2/3}$

b. $L_{coll} = A/(N\sigma_{natural}) = 26.5\ g\ cm^{-2} \times A^{1/3}$

NOTE: These quantities are calculated assuming a "nuclear radius" = $(\hbar/m_\pi c)\ A^{1/3} = (1.4f)\ A^{1/3}$. But attenuation of 25 GeV/c protons[m] and 20 GeV/c neutrons[n] is only 3/4 nominal.

c. From W. H. Barkas and M. J. Berger, Tables of Energy Losses and Ranges of Heavy Charged Particles, NASA SP-3013 (1964).

d. Mainly from O. I. Dovzhenko and A. A. Pomanskii, Soviet Physics JETP 18, 187 (1964).

e. For liquid phase at 1 atm. and boiling temperature.

f. Density variable.

g. At 20° C.

h. May vary by about ±3%, depending on operating conditions.

i. From F. R. Huson, Ionization Loss, Range, Straggling and Multiple Scattering, BNL 11386 (1967).

j. 53.7 atomic percent Ne.

k. Density of gas at STP = $0.900 \times 10^{-3}\ g\ cm^{-3}$, i.e., 0.75×10^{-3} times the density (1.200) of the boiling liquid.

ℓ. Typical scintillator; e.g., PILOT B has an atomic ratio H/C = 1.1.

m. G. Cocconi, Proc. 1960 Rochester Conf., p. 804, Fig. 6, find for attenuation, r (nuclear) = $1.23\ A^{1/3}$.

n. J. Engler et al., Nucl. Instr. and Meth. 106, 189 (1973) report $\lambda(Fe) = (17.1 \pm 0.3)$ cm, $\lambda(\text{Scintillator}) = (68.5 \pm 1.5)$ cm.

MULTIPLE COULOMB SCATTERING*

The rms projected angle θ due to multiple Coulomb scattering (only) of a particle of charge z (in units of electron charge), momentum p (in MeV/c), and velocity v (in units of c) is

$$\theta_{proj} = z \frac{15}{pv} \sqrt{\frac{L}{L_{rad}}}\ (1 + \epsilon)\ \text{radians};$$

where L = length in scatterer.

For $L \geqslant 1/10\ L_{rad}$, ϵ is generally $< 1/10$. The distribution of θ is not truly Gaussian.†

The rms projected displacement y on traversing an absorber of thickness L is

$$y_{rms} = L\theta_{proj}/\sqrt{3}.$$

---

*Mainly from G. Z. Molière, Naturforsch. 3(a), 78 (1948).

†See, for example, the experimental work of A. D. Hansen, L. H. Lanzl, E. M. Lyman, and M. B. Scott, Phys. Rev. 84, 634 (1951).

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 × QF,

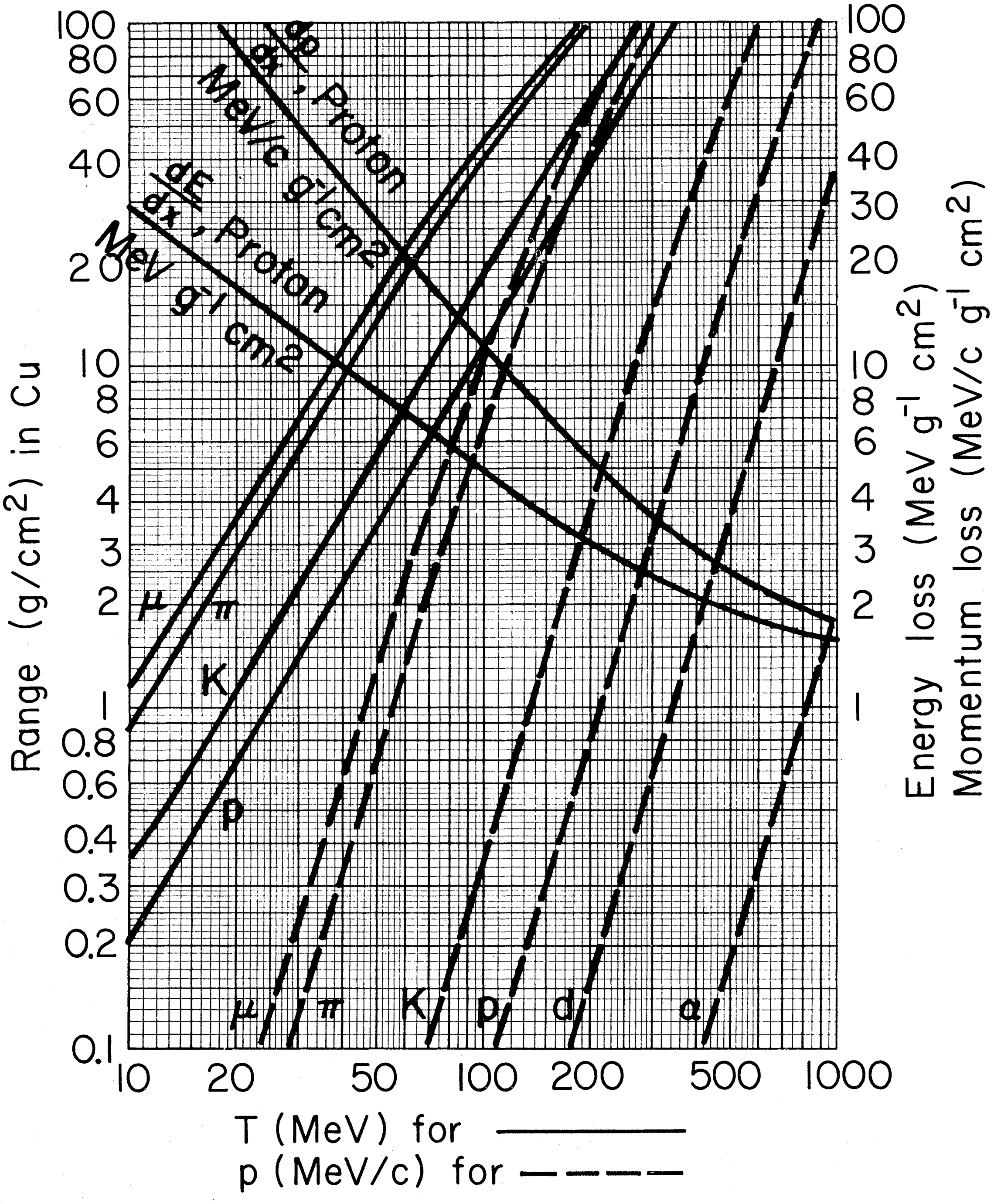
where QF (quality factor) depends upon the type of radiation and other factors. For γ rays and HE protons, QF ≈ 1; for thermal neutrons, QF ≈ 3; for fast neutrons, QF ranges up to 10; and for α particles and heavy ions, QF ranges up to 20.

Maximum permissible occupational dose for the whole body:
  5 rem/year (or ≈ 100 millirem/week)
Fluxes (per cm^2) to liberate 1R in carbon:
  3×10^7 minimum ionizing singly charged particles
  0.9×10^9 protons 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
  cosmic radiation (γ rays) ~25
  radiation from rocks and air (γ rays) ~73
  mrem/yr
Cosmic ray background in counters: ~ 1/min/cm^2/ster

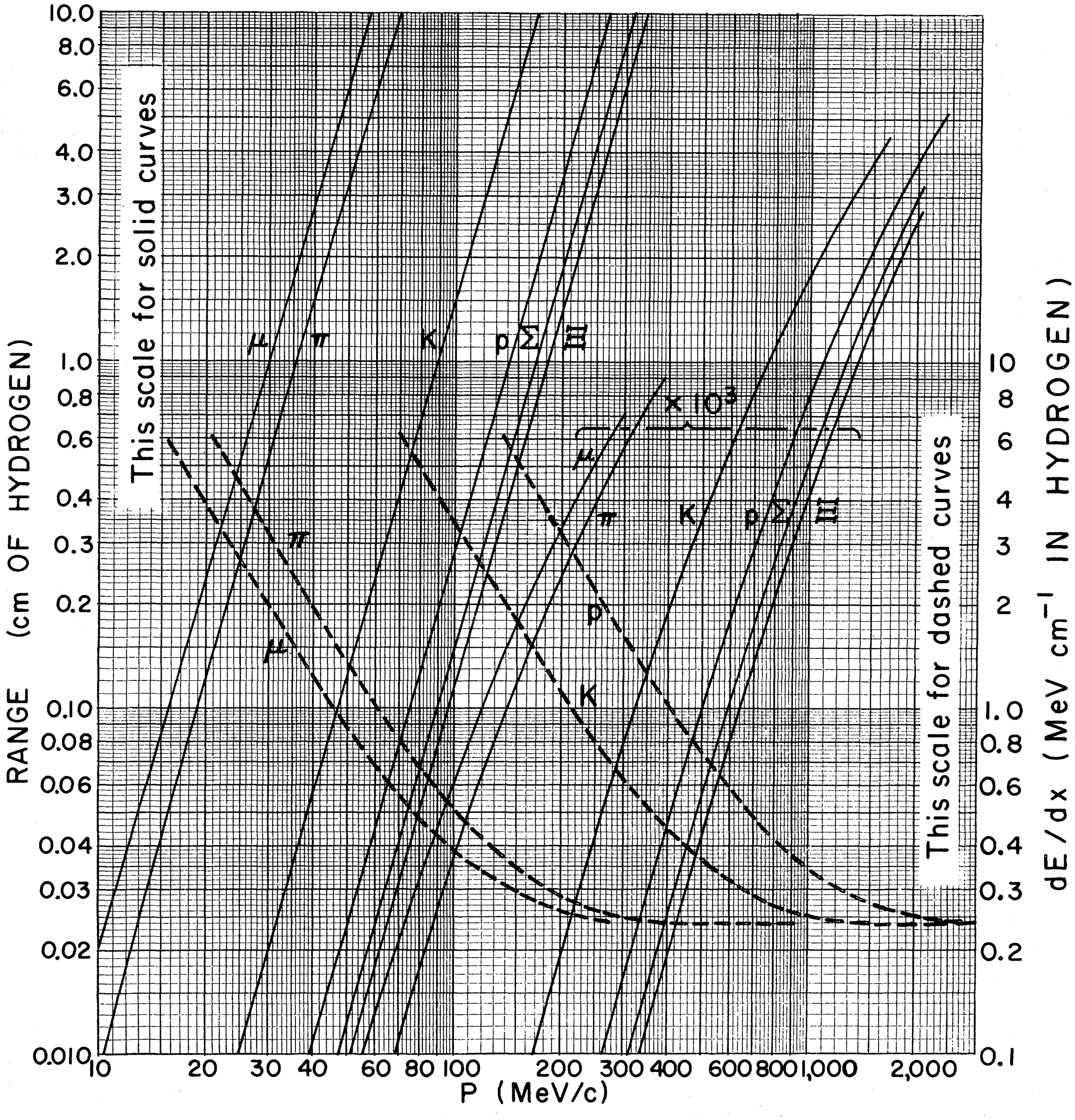
RANGE AND ENERGY LOSS IN COPPER



Range and energy/momentum loss in copper, based on a calculation assuming a nominal mean excitation potential of 310 eV. (Calculation by W. A. Aron, UCRL-1325, 1951). The abscissa is to be read as kinetic energy T for the solid curves and momentum p for the dashed curves.

See scaling law at bottom of next page.

RANGE AND ENERGY LOSS IN LIQUID HYDROGEN

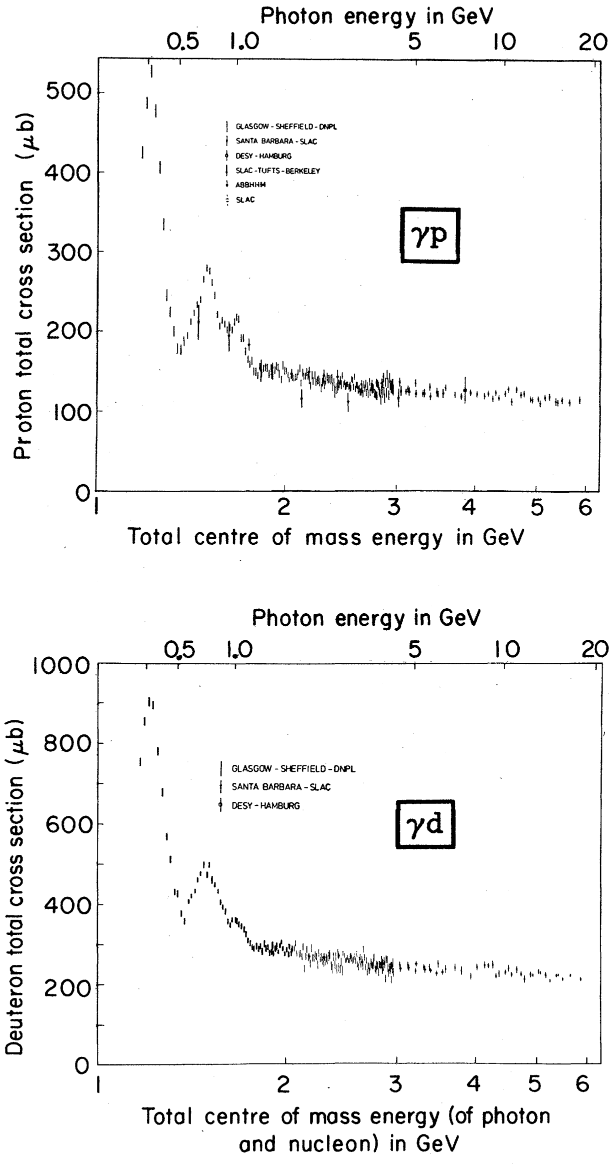


Range and energy loss in liquid hydrogen bubble chamber, determined by a μ^+ range of 1.103 ± 0.003 cm from the $\pi^+ \rightarrow \mu^+\nu$ decay. Liquid hydrogen conditions: $T = 27.6 \pm 0.1$°K; $P = 48 \pm 5$ psia; $\rho = (5.86 \pm 0.06)10^{-2}$g/cm^3. (Data by Clark and Diehl, UCRL-3789, 1957.) Bubble chamber physicists: note that the number of bubbles per cm is proportional to $1/\beta^2$, not to dE/dx.

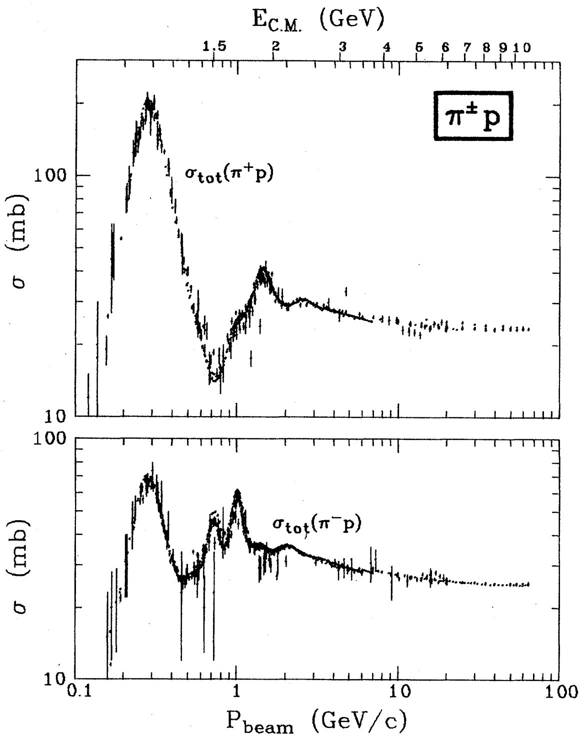
Scaling law for particles of other mass or charge: for a given medium, the range R_b of any beam particle with mass M_b, charge z_b, and momentum p_b is given in terms of the range R_a of any other particle with mass M_a, charge z_a, and momentum $p_a = p_b M_a/M_b$ (i. e., having the same velocity) by the expression

$$R_b(M_b, z_b, p_b) = \left[\frac{M_b/M_a}{z_b^2/z_a^2}\right] R_a(M_a, z_a, p_a = p_b M_a/M_b).$$

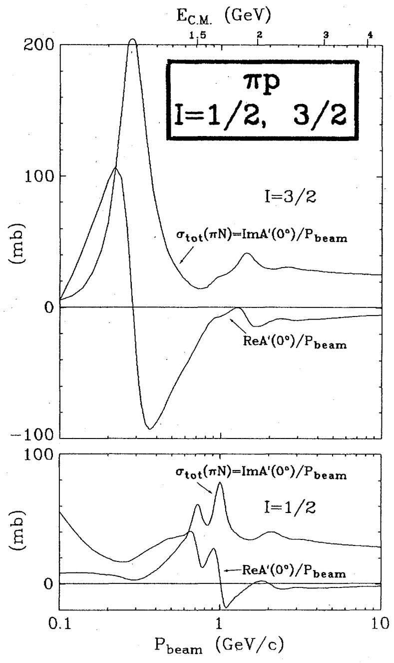
CROSS SECTION PLOTS



$\sigma_{tot}(\gamma p)$ and $\sigma_{tot}(\gamma d)$ as compiled by G. M. Lewis, Glasgow.

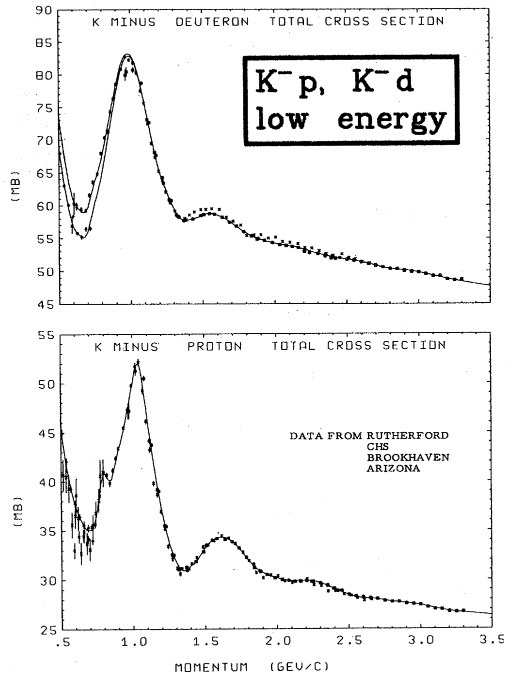


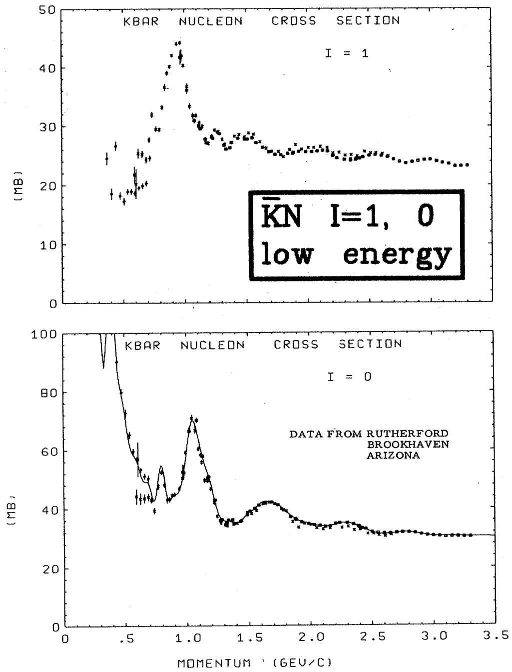
πN total cross section data from the compilation of C. Lovelace, et al. (see Sec. VI C of the text).



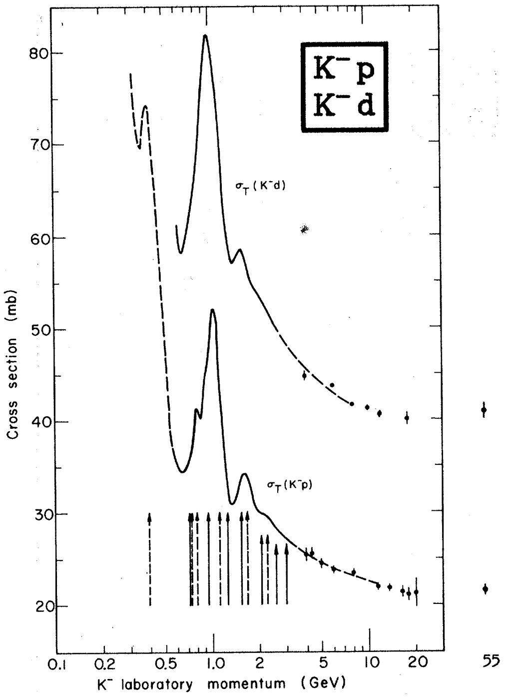
A smooth interpolation of the πN total cross sections for I=3/2 and I=1/2, and the corresponding real parts of the forward amplitudes as calculated from dispersion relations by G. Höhler and H. P. Jakob (private communication). The normalization of the curves for each value of I is such that the sum of their squares divided by 19.6 gives $d\sigma/dt$ at 0° in mb/(GeV/c)^2.

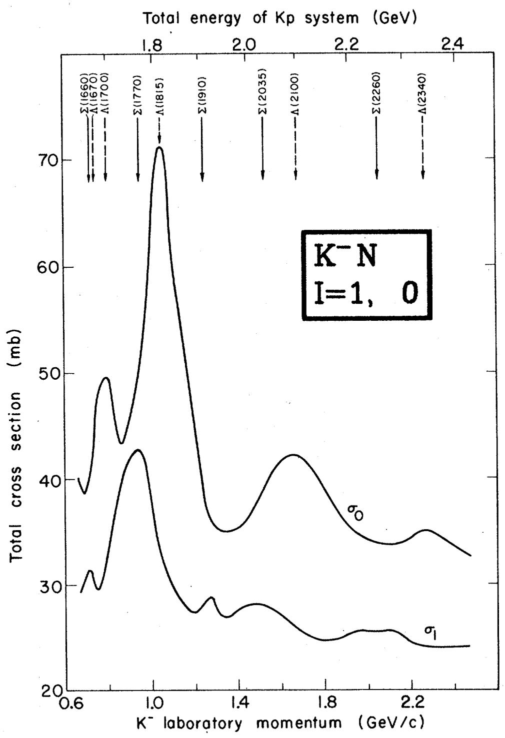
CROSS SECTION PLOTS





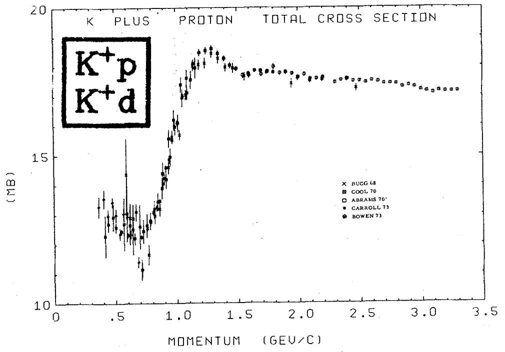
Compiled and unfolded by G. R. Lynch, Proc. 1970 Duke Baryon Conference.

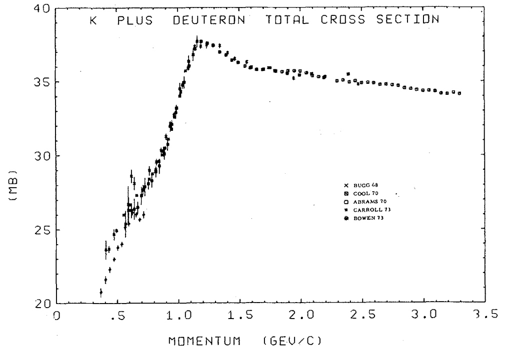




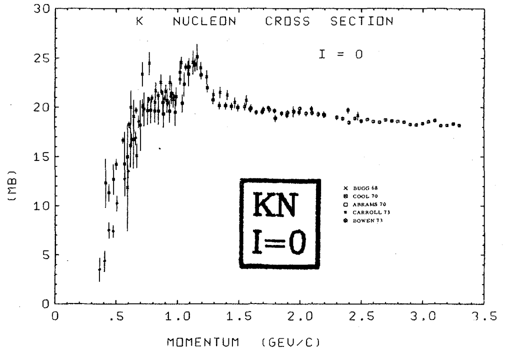
From A. Barbaro-Galtieri in Advances in Particle Physics, Vol. 2, edited by R. L. Cool and R. E. Marshak (Wiley & Sons, 1968). The points at 55 GeV/c are taken from IHEP-CERN Collab., Phys. Letters 30B, 500 (1969).

CROSS SECTION PLOTS

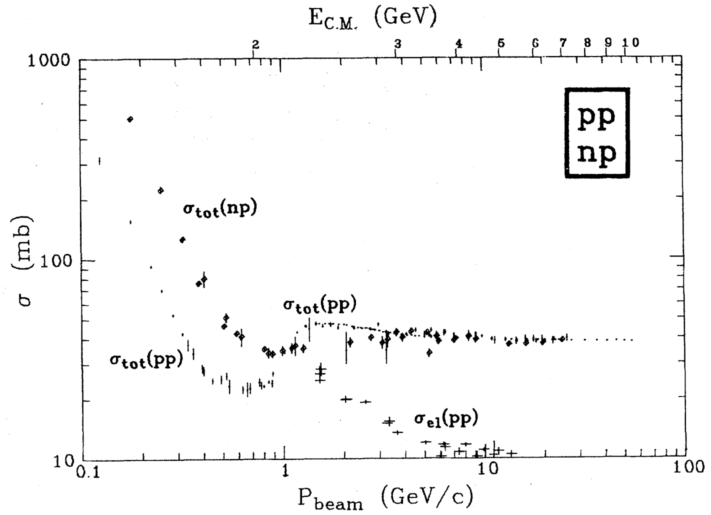




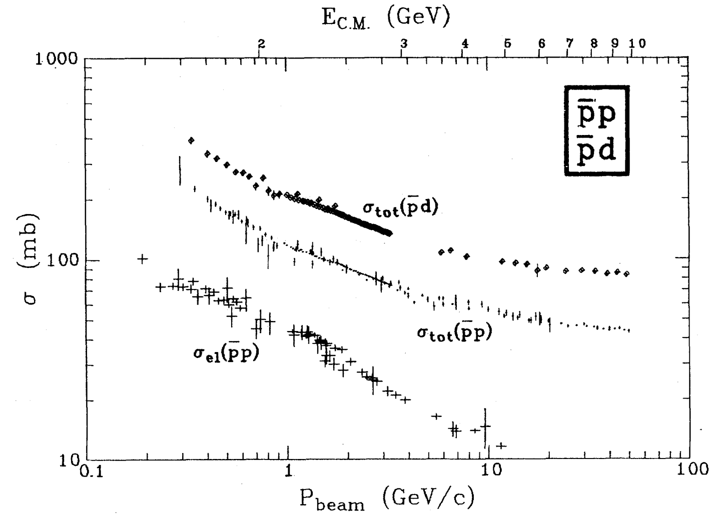
Compilation of recent K^+p and K^+d total cross-section measurements. References can be found in the Baryon Data Card Listings.



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 Baryon Data Card Listings).



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.



$\bar{p}p$ and $\bar{p}d$ cross sections from Particle Data Group, "A Compilation of $\bar{N}N$ and $\bar{N}D$ Reactions", LBL-58 (1972).

DATA CARD LISTINGS

Illustrative Key

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).

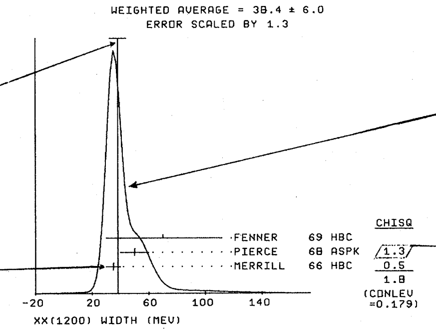
```
 XX(1200)   74 XX MESON (1200,JPG=  -)  I=1
                ORIGINALLY CALLED XXX
 ────────>      OMITTED FROM TABLE
------ --------- --------- --------- --------- --------- --------- --------

                 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               (1208.)                    FENNER    69 HBC    0 4.2 PI+P          9/69
M    S        80 1210.        8.           SMITH     70 MMS    - 3.5 PI-P          1/73*
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          1/73*
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           1/73*
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                     (SACLAY+CERN)
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)
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
```

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).

Branching ratio R_j in terms of partial decay mode fractions P_i above.

Author(s)

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 Reviews of Nuclear Science
BAPS	Bulletin of the American Physical Society
JETP	English Translation of Soviet Physics JETP
JETPL	Letters to Soviet Physics JETP
LNC	Letters to Nuovo Cimento
NC	Nuovo Cimento
NP	Nuclear Physics
PL	Physics Letters
PN	Particles and Nuclei
PPSL	Proceedings of the Physical Society of London
PR	Physical Review
PRL	Physical Review Letters
PRSL	Proceedings of the Royal Society of London
RMP	Reviews of Modern Physics
SJNP	Soviet Journal of Nuclear Physics
ZPHY	Zeitschrift für Physik

Measurement techniques

ASPK	Automatic spark chambers
CC	Cloud chamber
CNTR	Counters, electronics
DBC	Deuterium bubble chamber
DPWA	Energy-dependent partial wave analysis
EMUL	Emulsions
HBC	Hydrogen bubble chamber
HEBC	Helium bubble chamber
HLBC	Heavy liquid bubble chamber
IPWA	Energy-independent partial wave analysis
MMS	Missing mass spectrometer
MPWA	Model-dependent partial wave analysis
OSPK	Optical spark chambers
RVUE	Review of previous experimental data
STRC	Streamer chamber

Conferences

Conferences are referred to by the location in which they were held (e.g., DUBNA, BOULDER, LUND, etc.).

Institutions

AACH	TECHNISCHE UNIV. AACHEN	AACHEN, GERMANY
AERE	ATOMIC ENERGY RES. ESTAB.	HARWELL, BERKS., ENGLAND
AMST	UNIV. OF AMSTERDAM	AMSTERDAM, NETHERLANDS
ANKA	MIDDLE EAST TECHNICAL UNIV.	ANKARA, TURKEY
ANL	ARGONNE NAT. LAB.	ARGONNE, ILL., USA
ARIZ	UNIV. OF ARIZONA	TUCSON, ARIZ., USA
ATEN	NUCLEAR RES. CENTRE DEMOKRITOS	ATHENS, GREECE
BARI	UNIV. DEGLI STUDI DI BARI	BARI, ITALY
BELG	INST. INTERUNIV. DES SCI. NUC.	BRUXELLES, BELGIUM
BERG	FYSISK INSTITUTT	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 INSTITUTE	COPENHAGEN, DENMARK
BONN	UNIV. BONN	BONN, GERMANY
BOST	BOSTON UNIV.	BOSTON, MASS., USA
BRAN	BRANDEIS UNIV.	WALTHAM, MASS., USA
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 INSTITUTE OF PHYSICS	BUDAPEST, HUNGARY
BUFF	STATE UNIV. OF NEW YORK AT BUFFALO	BUFFALO, N. Y., USA
CAEN	LAB. DE PHYS. CORPUSCULAIRE	CAEN, FRANCE
CARL	CARLTON UNIV.	OTTAWA, CANADA
CARN	CARNEGIE-MELLON UNIV.	PITTSBURGH, PA., USA
CASE	CASE WESTERN RESERVE UNIV.	CLEVELAND, OHIO, USA
CAVE	CAVENDISH LAB., CAMBRIDGE UNIV.	CAMBRIDGE, ENGLAND
CDEF	COLLEGE DE FRANCE	PARIS, FRANCE
CEA	CAMBRIDGE ELECTRON ACCEL.	CAMBRIDGE, MASS., USA
CERN	EUROPEAN ORG. FOR NUC. RES.	GENEVA, SWITZERLAND
CHIC	UNIV. OF CHICAGO	CHICAGO, ILL., USA
CINC	UNIV. OF CINCINNATI	CINCINNATI, OHIO, USA
CIT	CALIF. INSTITUTE 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
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 NUC. PHYS. LAB.	DARESBURY, ENGLAND
DART	DARTMOUTH COLLEGE	HANOVER, N. H., USA
DESY	DEUTSCHES ELEKTRONEN-SYNCH.	HAMBURG, 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
ETHZ	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
FRAS	LAB. NAZIONALI DEL SINCROTRONE	FRASCATI, ITALY
FSU	FLORIDA STATE UNIV.	TALLAHASSEE, FLA., USA
GENO	UNIV. DI GENOVA	GENOVA, ITALY
GEVA	UNIV. DE GENEVE	GENEVA, SWITZERLAND
GLAS	UNIV. OF GLASGOW	GLASGOW, SCOTLAND
GRAZ	UNIV. GRAZ	GRAZ, AUSTRIA
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
IIT	ILLINOIS INST. OF TECH.	CHICAGO, ILL., USA
ILL	UNIV. OF ILLINOIS	URBANA, ILL., USA
ILLC	UNIV. OF ILLINOIS AT CHICAGO	CHICAGO, ILL., USA
IND	UNIV. OF INDIANA	BLOOMINGTON, IND., USA
IOWA	UNIV. OF IOWA	IOWA CITY, IOWA, USA
IPN	INST. DE PHYS. NUCLEAIRE	ORSAY, FRANCE
IPNP	INSTITUT DE PHYSIQUE NUCLEAIRE	PARIS, FRANCE
IRAD	INSTITUTE 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	TECHNISCHE UNIV. KARLSRUHE	KARLSRUHE, GERMANY
KNTY	UNIV. OF KENTUCKY	LEXINGTON, KY., USA
LANC	LANCASTER UNIV.	LANCASTER, ENGLAND
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
LEBD	LEBEDEV PHYSICS INST.	MOSCOW, USSR
LEHI	LEHIGH UNIV.	BETHLEHEM, PA., USA
LEID	INST. LORENTZ	LEIDEN, NETHERLANDS
LINZ	LINZ INSTITUT FUR PHYSIK, KEPLER HOCH.	LINZ, AUSTRIA
LIVP	LIVERPOOL UNIV.	LIVERPOOL, ENGLAND
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
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
MANH	MANHATTAN COLLEGE	NEW YORK, N. Y., USA
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
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	ISTITUTO DI FISICA DELLA UNIVERSITA	MODENA, ITALY
MPIM	MAX-PLANCK-INST. FUR PHYS.-ASTROPHYS.	MUNICH, GERMANY
MSNA	INS. DI FISICA DELL UNIV.	MESSINA, ITALY
MSU	MICHIGAN STATE UNIV.	EAST LANSING, MICH., USA
NAGO	NAGOYA UNIV.	NAGOYA, JAPAN
NAL	NATIONAL ACCELERATOR LAB.	BATAVIA, ILL., USA
NAPL	UNIV. DI NAPOLI	NAPOLI, ITALY
NDAM	UNIV. OF NOTRE DAME	NOTRE DAME, IND., USA
NEAS	NORTHEASTERN UNIV.	BOSTON, MASS., USA
NEVI	NEVIS LAB.	IRVINGTON-ON-HUDSON, N.Y., USA
NIJM	R. K. UNIV. NIJMEGEN	NIJMEGEN, NETHERLANDS
NORD	NORDISK INS. FOR TEOR. ATOMFYS.	COPENHAGEN, DENMARK
NOVO	INST. OF NUCL. PHYS.	NOVOSIBIRSK, USSR
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
OSLO	OSLO UNIV.	OSLO, NORWAY
OSU	OHIO STATE UNIV.	COLUMBUS, OHIO, USA
OXF	OXFORD UNIV.	OXFORD, ENGLAND
PADO	UNIV. OF PADOVA	PADOVA, ITALY
PATR	UNIV. OF PATRAS	PATRAS, GREECE
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	INSTITUTE OF PHYSICS, CSAV	PRAGUE, CZECHOSLOVAKIA
PRIN	PRINCETON UNIV.	PRINCETON, N. J., USA
PURD	PURDUE UNIV.	LAFAYETTE, IND., USA
REHO	WEIZMANN INST. OF SCI.	REHOVOTH, ISRAEL
RHEL	RUTHERFORD HIGH ENERGY LAB.	CHILTON, DID., BERKS., ENGLAND
RISO	RESEARCH ESTAB. RISO	ROSKILDE, DENMARK
ROCH	UNIV. OF ROCHESTER	ROCHESTER, N. Y., USA
ROMA	UNIV. DEGLI STUDI DI ROMA	ROME, ITALY
RUTG	RUTGERS UNIV.	NEW BRUNSWICK, N. J., USA
SACL	CNTR. D'ETUDES NUC. SACLAY	GIF-SUR-YVETTE, FRANCE
SEAT	SEATTLE PACIFIC COLLEGE	SEATTLE, WASH., USA
SERP	INST. OF HIGH EN. PHYS.	SERPUKOV, USSR
SETO	SETON HALL UNIV.	SOUTH ORANGE, N. J., USA
SHMP	UNIV. OF SOUTHAMPTON	SOUTHAMPTON, ENGLAND
SLAC	STANFORD LINEAR ACCEL. CENTER	STANFORD, CALIF., 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
SUSS	SUSSEX UNIV.	SUSSEX, ENGLAND
SYRA	SYRACUSE UNIV.	SYRACUSE, N. Y., USA
TELA	UNIV. OF TEL-AVIV	TEL-AVIV, ISRAEL
TENN	UNIV. OF TENNESSEE	KNOXVILLE, TENN., USA
TNTO	UNIV. OF TORONTO	TORONTO, CANADA
TOHO	TOHOKU UNIV.	SENDAI, JAPAN
TOKY	UNIV. OF TOKYO	TOKYO, JAPAN
TORI	UNIV. DI TORINO	TORINO, ITALY
TRST	UNIV. OF TRIESTE	TRIESTE, ITALY
TUFT	TUFTS UNIV.	MEDFORD, MASS., USA
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
UPNJ	UPSALA COLLEGE	EAST ORANGE, N. J., USA
UTAH	UNIV. OF UTAH	SALT LAKE CITY, UTAH, USA
VAND	VANDERBILT UNIV.	NASHVILLE, TENN., USA
VIEN	INST. FOR HIGH EN. PHYS., 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
WUSL	WASHINGTON UNIV.	ST. LOUIS, MO., USA
WYOM	UNIV. OF WYOMING	LARAMIE, WYOMING, USA
YALE	YALE UNIV.	NEW HAVEN, CONN., USA
ZEEM	ZEEMAN LAB., UNIV. OF AMSTERDAM	AMSTERDAM, NETHERLANDS

Data Card Listings

For notation, see key at front of Listings.

Stable Particles

γ, ν_e, ν_μ, e, μ

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CODE EVENTS QUANTITY  ERROR+  ERROR-  REFERENCE YR TECN SIGN COMMENTS  DATE
    ABOVE                                                            PUNCHED
  BACKGROUND

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$\boxed{\gamma}$

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                      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   F   VALIDITY QUESTIONABLE ACCORDING TO AUTHORS AND KROLL 71.                  3/72
M   P   SEE CRITICISM IN GOLDHABER 71                                             3/72

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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)

                           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)

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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
M            (0.15) OR LESS              HAMILTON  53 CNTR
M            (0.55)   (0.28)             FRIEDMAN  58 CNTR
M             0.06  OR LESS  CL=.90      BERGKVIS  69 CNTR    EL.STATIC.MAG.SP 11/69

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                           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)
BERGKVIS 69 CERN 69-7 91      KARL-ERIK BERGKVIST        (UNIV STOCKHOLM)

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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            (0.46)   (0.64)    (0.46)   FRANK     68 CNTR    PRELIMINARY       9/68
M   B        (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   B         1.15   OR LESS  CL=.90     BACKENSTO 73 CNTR    M**2=-0.29+-0.90  1/73*
M   B   BACKENSTOSS 73 REPLACES BACKENSTOSS 71 AND USES THEIR NEW PI- MASS.    1/73*
M   B   WE CALCULATE UPPER LIMIT FROM M**2.                                     1/73*
M   S   SHRUM 71 USES SHAFER 67 PI- MASS VALUE AND CRANE 71 MU MASS VALUE.     1/73*

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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)

SHAFER   65 PRL  14 923       R E SHAFER,CROWE,JENKINS               (LRL)
BOOTH    67 PL 26B  39        BOOTH,JOHNSON,WILLIAMS,WORMALD  (LIVERPOOL)
HYMAN    67 PL 25B 376        +LOKEN,PEWITT,MCKENZIE+      (ANL+CARN+NWES)
FRANK    68  VIENNA ABS.  365 FRANK,GAMET,LAKIN            (SHMP+LIVP+STAN)
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)
BACKENST 73 SUBMITTED TO PL B BACKENSTOSS,DANIEL,KOCH+ (CERN,KARL,MUNICH)

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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

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                      3  ELECTRON MEAN LIFE (UNITS 10**21 YR)

T              2.0  OR MORE              MOE       65 CNTR                      6/66

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                      3  ELECTRON MAGNETIC MOMENT(E/2ME)

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 R    RICH 68 IS REEVALUATION OF WILKINSON 63.

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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)
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)

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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                      1/73*
M     D      105.6594   0.0004           CROWE     72 CNTR                      2/72
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           . . . . . . . . . .
M    AVG     105.65952  0.00031  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    FIT     105.6595    .0003 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)   1/73*

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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             2.20026  0.00081           WILLIAMS  72 CNTR +                    2/72
T           . . . . . . . . . .
T    AVG      2.19936  0.00061   0.00061 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.1)

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                      4  MU+/MU- MEAN LIFE RATIO

DT             1.000    0.001            MEYER     63 CNTR  MEAN LIFE MU+/MU-   7/66

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                      4  MUON ANOMALOUS MAGN. MOMENT (10**-6*E/(2*MU MASS))

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

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                      4  MUON 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)(.000034)            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     3.183349  .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 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    3.1833447 .0000061  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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Stable Particles

μ, $\pi^{\pm}$

Data Card Listings

For notation, see key at front of Listings.

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                    4  MUON PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      MUON INTO E (E-NEU) (MU-NEU)                        .5+   0+    0
P2      MUON INTO E 2GAMMA                                  .5+   0+    0
P3      MUON INTO 3ELECTRONS                                .5+  .5+   .5
P4      MUON INTO E GAMMA                                   .5+   0

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                    4  MUON BRANCHING RATIOS

R1      MUON INTO E+2GAMMA (IN UNITS OF 10**-5)          (P2)/(P1)
R1            (1.6)  OR LESS  CL=.90   FRANKEL1  63 OSPK

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     KORENCHENKO2 71 ASSUMES A CONSTANT MATRIX ELEMENT.                 2/72
R2 F     FOUR ABOVE EXPERIMENTS EVALUATED UPPER LIMITS ASSUMING A SECOND
R2       ORDER V-A NEUTRINO LOOP DIAGRAM. LIMITS NOT SIGNIFICANTLY CHANGED B
R2       ASSUMING A CONSTANT MATRIX ELEMENT.

R3      MUON 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

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                    4  MUON DECAY PARAMETERS

        RELATED TEXT SECTION IV E


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)

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)

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)

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)

GS      SCALAR COUPLING CONSTANT IN MUON DECAY  (IN UNITS OF GV)
GS             (0.33) OR LESS           DERENZO    69 RVUE                     10/69

GAV     AXIAL VECTOR COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)
GAV             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

COFFIN   58 PR 109 973         +GARWIN,PENMAN,LEDERMAN,SACHS    (COLUMBIA)
LUNDY    58 PRL 1 38           +SENS,SWANSON,TELEGDI,YOVANOVITCH (CHICAGO)
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)
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+      (KURCHATOV,MOSCOW)
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)
GUREVICH 67  IAE 1297          GUREVICH,MAKARIYNA,MISHAKOVA+   (KURCHATOV)
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)
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)

                               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)

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 π±                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     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    AVG      139.5682   0.0068  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    FIT      139.5688   0.0064 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)   1/73*

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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            . . . . . . . . . .
D    AVG       33.915    0.019   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D    FIT       33.909    0.006  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)   1/73*

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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          . . . . . . . . .
T   AVG      26.024   0.024   0.024  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)

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                    8  ((PI+) - (PI-))/AVG., MEAN LIFE DIFFERENCE (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)

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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             1.247    0.028       DI CAPUA  64 CNTR
R2          . . . . . . . . .
R2  AVG        1.242    0.026   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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)
    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      143    3.0      0.5         DEPOMMI2  63 CNTR    GAM KE 50-90 MEV  6/66

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

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                          REFERENCES FOR CHARGED PION

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)
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 B4 189          DEPOMMIER,DUCLOS,HEINTZE,KLEINKNECHT+(CERN)
PETRUKHI 68 JINR-P1-3862       PETRUKHIN,RYKALIN,KHAZINS,CISEK       (DUBNA)
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)
BOOTH    70 PL 32B 723         +JOHNSON,WILLIAMS,WORMALD              (LIVP)
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)
BACKENST 73 SUBMITTED TO PL B  BACKENSTOSS,DANIEL,KOCH+ (CERN,KARL,MUNICH)
    ALSO 73 SUBMITTED TO NP    L. TAUSCHER
SHAFER   72 PRIVATE COMM.      R. SHAFER, 1972
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                       PAPERS NOT REFERRED TO IN DATA CARDS

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)
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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)

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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. ON NUC  7/70
T            0.9      0.068         KRYSHKIN  70 CNTR    PRIMAKOFF EFFECT 12/70
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          . . . . . . . . .
T   AVG      0.839    0.103    0.092  AVERAGE (ERROR INCL. SCALE FACTOR OF 2.1)
                      (SEE IDEOGRAM BELOW )
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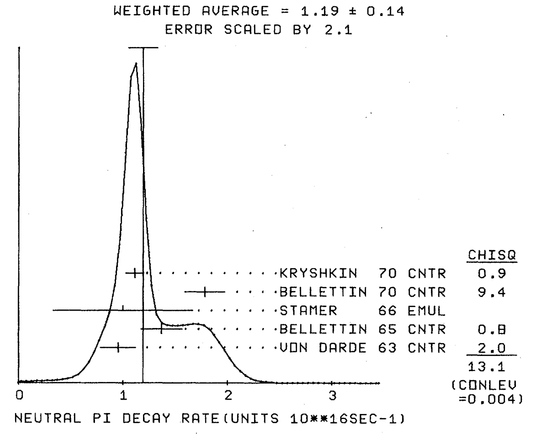

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                    9  NEUTRAL PION PARTIAL DECAY MODES

                                                          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

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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)

R2      PIO INTO (3 GAMMA)/(2 GAMMA) (UNITS 10**-6)      (P4)/(P1)
R2        0    5.0    OR LESS  CL=.90   DUCLOS    65 CNTR                 6/66
R2             5.0    OR LESS  CL=.90   KUTIN     65 CNTR                 3/68

R3      PIO INTO (E+E+E-E-)/(2 GAMMA) (UNITS 10**-5)     (P3)/(P1)
R3           (3.47)  THEORETICAL CAL. KROLL     55       QUANTUM ELECT.    9/66
R3      146    3.18     0.30          SAMIOS    62 HBC   SEE NOTE N BELOW  6/66
R3  N   ABOVE VALUE USES PANOFSKY RATIO = 1.62

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                              REFERENCES FOR NEUTRAL PION

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)
KROLL    55 PR 98 1355        N KROLL ,W WADA              (COLUMBIA+NRL)
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)
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)
BELLETTI 70 NC 66A 243        BELLETTINI,BEMPORAD,LUBELSMEY+  (PISA+BONN)
KRYSHKIN 70 JETP 30 1037      +STERLIGOV,USOV       (TOMSK POLYTECH.INST.)

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$K^{\pm}$

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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           493.87     0.19            KUNSELMAN 71 CNTR  - KAONIC ATOMS     10/71
M           493.691    0.040           BACKENSTO 73 CNTR  - KAONIC ATOMS     1/73*
M          . . . . . . . . .
M   AVG     493.709    0.037   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   FIT     493.715    0.037  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  1/73*

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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   FIT        1.2371   0.0026 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)
                        (SEE IDEOGRAM BELOW )
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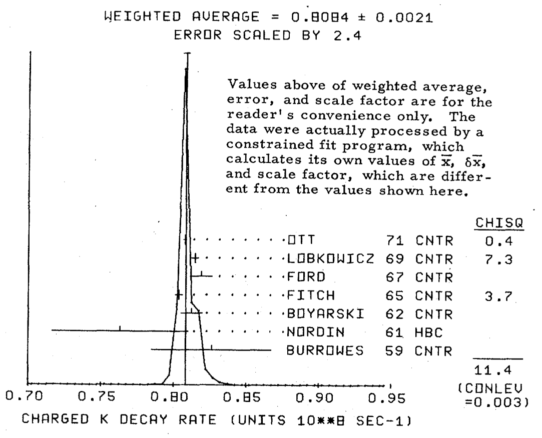

Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\overline{x}$, $\delta\overline{x}$, and scale factor, which are different from the values shown here.

```
                  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)

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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 INTO 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 INTO MU NEU GAMMA          K MU RAD       105+   0+   0
P13     CHAR. K INTO 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 PI E NEUTRINO GAMMA   PI E NEU GAM   139+  .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

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                 CHARGED K CONSTRAINED FIT
            OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING
            RATIOS USES 52 DATA POINTS TO DETERMINE SIX
            QUANTITIES.  OVERALL FIT HAS  CHISQ=82.2.  MAIN
            CONTRIBUTION (16.3) COMES FROM R19 OF HAIDT
            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 .6352+-.0019
P 2   -.7953   .2106+-.0018
P 3   -.1750     -.0694   .0559+-.0003
P 4   -.1814     -.0728      .1456  .0173+-.0005
P 5   -.2968     -.1830      .0439    -.0155  .0324+-.0010
P 6   -.2852     -.1793      .1199    -.0085      .4265  .0485+-.0006
```

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 .5135+-.0019
G 2   -.4575   .1702+-.0015
G 3   -.1104     -.0435   .0452+-.0002
G 4   -.1284     -.0607      .1396  .0140+-.0004
G 5   -.2040     -.1598      .0464    -.0142  .0262+-.0008
G 6   -.1399     -.1299      .1207    -.0059      .4297  .0392+-.0005


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                  10  CHARGED K DECAY RATES

W1      CHAR. K INTO MU NEU (UNITS 10**6 SEC-1)          (G1)
W1          51.2       0.8            FORD       67 CNTR +-                     8/67
W1         . . . . . . . . .
W1  FIT     51.35      0.19   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     4.520     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     0.043   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       6.542     0.083   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             0.08      0.12           FORD      70 ASPK    SEE NOTE F     11/70
D2   F   THE LAST IS THE COMBINED RESULT OF FORD 67 AND FORD 70
D2               . . . . . . . . .
D2   AVG       0.07      0.12     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

D3      DIFFERENCE IN TAU PRIME RATES ((G4+)-(G4-))/AVERAGE    (PERCENT)
D3     1802   -1.1      1.8             HERZO     69 OSPK                    5/70

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*

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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       63.52     0.19   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       21.06     0.18   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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   FIT       5.591     0.030  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                         (SEE IDEOGRAM BELOW )
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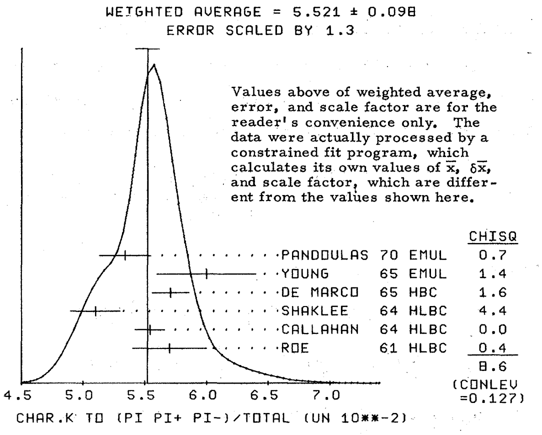

Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\bar{x}$, $\delta\bar{x}$, and scale factor, which are different from the values shown here.

```
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   FIT       1.735     0.049  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)
                         (SEE IDEOGRAM BELOW )
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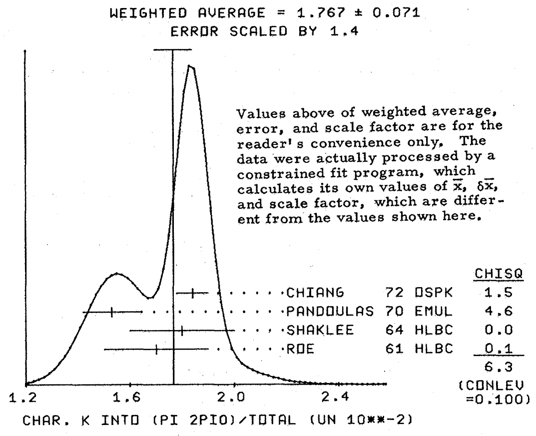
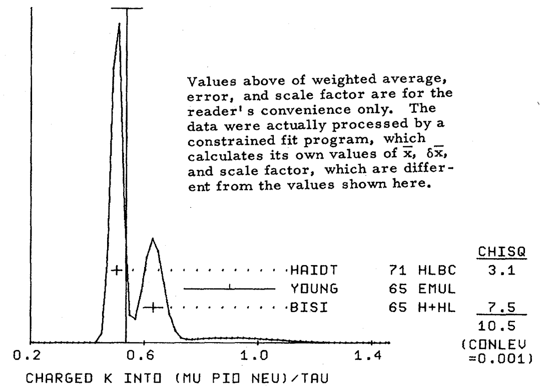


Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\bar{x}$, $\delta\bar{x}$, and scale factor, which are different from the values shown here.

```
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       3.24      0.10   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)

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   FIT       4.851     0.055  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   FIT       24.30     0.19   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            1.1     OR LESS  CL=.95  CHEN       68 OSPK +  T(PI) 60-90 MEV   5/68
R12            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      72 HLBC +  6-102,114-127MEV  2/72

R13     CHAR. K INTO (PI PIO GAMMA)/TOTAL (UNITS 10**-4) (P13)
R13      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  A2100     2.71      0.19           ABRAMS     72 ASPK +- PI+ KE 55-90 MEV  1/73*
R13      24    2.4       0.8            EDWARDS    72 OSPK    PI+ KE 58-90 MEV  8/72*
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        2.66      0.18     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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            0.4     OR LESS          CLINE      67 FBC  +                  11/67
R15           32.0     OR LESS  CL=.90  BEIER      72 OSPK +-                  9/72*

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 (E PIO NEU)/(MU2+PI2) (UNITS 10**-2)(P6)/(P1+P2)
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 FIT        3.767     0.040  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 FIT        0.3103    0.0087 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

R19     CHAR. K INTO (MU PIO NEU)/TAU                       (P5)/(P3)
R19   2175     0.632     0.035          BISI      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 FIT        0.580     0.018  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)
                         (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.536 ± 0.054
ERROR SCALED BY 3.2



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.

```
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  H  HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R20          . . . . . . . . .
R20 AVG        0.858     0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R20 FIT        0.868     0.010  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          . . . . . . . . .
R21 AVG        6.64      0.40    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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          . . . . . . . . .
R23 AVG        6.02      0.15    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R23 FIT        5.736     0.064  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R24     CHAR. K INTO (PI PIO)/(MU NEU)                      (P2)/(P1)
R24            0.3253    0.0065         AUERBACH  67 OSPK +                   8/67
R24   1600     0.305     0.018          ZELLER    69 ASPK +                  10/69
R24          . . . . . . . . .
R24 AVG        0.3230    0.0065  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R24 FIT        0.3316    0.0037 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R25     CHAR. K INTO (E PIO NEU)/(MU NEU)                   (P6)/(P1)
R25    472     0.0797    0.0054         AUERBACH  67 OSPK +                   8/67
R25      THE VALUE .0785+-.0025 GIVEN IN THE ABOVE REF IS AN AVERAGE OF
R25      AUERBACH 67 R25 AND CESTER 66 R23.
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          . . . . . . . . .
R25 AVG        0.0753    0.0025  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R25 FIT       0.07638   0.00085 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R26     CHAR. K INTO (MU PIO NEU)/(MU NEU)                  (P5)/(P1)
R26    310     0.0602    0.0046         AUERBACH  67 OSPK +                   8/67
R26    424     0.055     0.004          GARLAND   68 OSPK +                   4/68
R26    240     0.054     0.009          ZELLER    69 ASPK +                  10/69
R26          . . . . . . . . .
R26 AVG        0.0569    0.0029  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R26 FIT        0.0510    0.0016 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)

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       11.361     0.075   FROM FIT
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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    113     2.42      0.42            CLARK     72 OSPK +                  1/73*
R28          . . . . . . . . .
R28 AVG        2.16      0.31    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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 A 1398    (0.604)   (0.022)         EICHTEN   68 HLBC                    10/68
R29 AH        (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                   COMMENTS
R29  D  THIS VALUE IS STATISTICALLY INDEPENDENT OF CHIANG 72 R5 AND R6.       9/72*
R29  H  HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R29 A   ONLY INDIVIDUAL RATIOS INCLUDED IN FIT (SEE R19 AND R20).            11/68
R29  C  FROM THIS EXPERIMENT 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          . . . . . . . . .
R29 AVG        0.678     0.014   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R29 FIT        0.668     0.024  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.2)

R30     CHAR. K INTO (PI E NEU GAMMA)/(PI E NEU)          (P18)/(P6)
R30 R         (0.012)   (0.008)         BELLOTT1  67 HLBC +  EGAM GT 30MEV   11/67
R30  R  13     0.0076    0.0028         ROMANO    71 HLBC    EGAM GT 10MEV   10/71
R30 R   WE USE LOWEST E(GAMMA) CUT.SEE ROMANO 71 FOR DEPENDENCE ON THIS CUT  2/72

R31     K- INTO (PI+ E- E-)/TOTAL (UNITS 10**-5)          (P19)
R31      TEST OF LEPTON 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        (100.0)   OR LESS  CL=.90    CAMERINI  69 HLBC +  TEST NEUTR.CURR.  5/70
R32  K         1.4   OR LESS  CL=.90    KLEMS     71 OSPK +  T(PI) GT 117 MEV  8/71
R32  K  ASSUMES PI+ SPECTRUM SAME AS PIO SPECTRUM IN KE3 DECAY

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        3.223     0.090   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)         (P8)/(P7)           2/72
R37      0     0.013 OR LESS  CL=.95    BOURQUIN  71 ASPK                    12/71

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       5.1       1.3  CLINE     72 HLBC +                   2/72

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            7.0   OR LESS  CL=.90    CABLE     72 CNTR +                  10/72*

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Note on Slope Parameter for K → 3π Decays

As was discussed in Section IV F. 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

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

where

$$s_i = (\underline{p}_K - \underline{p}_i)^2 = (m_K - m_i)^2 - 2\,m_K T_i \qquad (2)$$

$$s_0 = \frac{1}{3}\sum s_i = \frac{1}{3}(m_K^2 + m_1^2 + m_2^2 + m_3^2) \qquad (3)$$

$\underline{p}_K$, $\underline{p}_i$ are the four-vectors for the K and the i^{th} pion, and the index 3 refers to the odd pion. (4)

We refer to the three possible charged decays as τ, τ', τ^0

$\tau^{\pm}$	$K^{\pm} \to \pi^{+}\pi^{-}\pi^{\pm}$
$\tau'^{\pm}$	$K^{\pm} \to \pi^{0}\pi^{0}\pi^{\pm}$
τ^{0}	$K_2^0 \to \pi^{+}\pi^{-}\pi^{0}$

where the odd pion is the third one.

There is no strong evidence so far that a second order term in (s_3-s_0) is needed in Eq. (1), nor that the term in (s_2-s_1) is present. A value of $j \neq 0$ indicates CP violation as would a value of g for τ^+ different from that for τ^-. The CP violation tests in τ decays are listed as $\frac{(g^+-g^-)}{(g^++g^-)}$ for charged K and as $\sigma^{\pm}$ for neutral K (see Sec. IV F. 3b in the text).

As for the coefficient h, most of the experimenters have fitted their data with a second order term, which turned out to be consistent with zero. We use the value of g obtained when the second order term was dropped from the fit. HEUSSE 70 have studied the $K_L^0 \to \pi^0\pi^0\pi^0$ decay where only a second order term could explain deviation from uniformity of the Dalitz plot. They also get results consistent with a zero coefficient. ALBROW 70 have studied $K_L^0 \to \pi^+\pi^-\pi^0$ and found that the fit to the Dalitz plot improves if second and third order terms are added (CL goes from 24% to 48%), but the fit with no higher orders is a perfectly acceptable one (CL = 24%). FORD 72 have studied $K^{\pm} \to \pi^{\pm}\pi^{\mp}\pi^{\pm}$ and find that the χ^2/DF goes from 1.38 to 1.20 when the second order and the 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.

In the literature <u>other definitions</u> of slope parameters have appeared. We have converted to the definition of g in Eq. (1) whatever experimental quantity has been reported. We give the conversion to the definition (1) for two of the most widely used parametrizations and tabulate the conversion factors for the reader's convenience.

(a) For analysis of charged K's the expression often used is:

$$|M|^2 = 1 + a_y Y$$

with

$$Y = \frac{3T_3-Q}{Q}\ , \quad Q = m_K - \sum m_i\ .$$

The relevant formulae are:

$$Y = -\frac{3}{2}\,\frac{s_3-s_0}{m_K Q} + \Delta, \text{ with } \Delta = \frac{m_{12}-m_3}{Q}\left(2 - \frac{m_3+m_{12}}{m_K}\right)$$

and

$$\boxed{g = \frac{-c_y a_y}{1+a_y \Delta}}\ , \quad \text{with } c_y = \frac{3}{2}\,\frac{m_{\pi^+}^2}{m_K Q}\ .$$

(b) For the analysis of K^0 decay the expression often used is:

$$|M|^2 = 1 + 2a_t \frac{m_K}{m_{\pi^+}^2}\left(2T_3 - T_{3\,max}\right)$$

with

$$T_{3\,max} = \frac{m_K^2 + m_3^2 - 4m_{12}^2}{2m_K} - m_3\ .$$

The relevant transformations are

$$T_3 = -\frac{s_3-s_0}{2m_K} + \frac{Q}{3}\,(1+\Delta)$$

and

$$\boxed{g = \frac{-2a_t}{1+a_t c_t}}\ , \quad \text{with } c_t = \frac{2m_K}{m_{\pi^+}^2}\left[\frac{2}{3}Q(1+\Delta) - T_{3\,max}\right].$$

For the reader's convenience we give a table of numerical values for Q, $T_{3\,max}$, Δ, c_y and c_t, obtained using the masses from our August 1970 edition. The g values quoted in these Data Card Listings would not be changed if the current mass values were used.

	Q	$T_{3\,max}$	Δ	c_y	c_t
$\tau^{\pm}$	74.96	48.15	0	0.7894	0.0924
$\tau'^{\pm}$	84.24	53.27	-0.0789	0.7025	-0.0778
τ^{0}	83.54	53.92	0.0798	0.7028	0.3176

Some K^0 authors use the above form of matrix element:

$$|M|^2 = 1 + 2a_u \frac{m_K}{m_{\pi^+}^2}\left(2T_3 - T_{3\,max}\right)\ ,$$

but define

$$T_{3\,max} = \frac{2}{3}Q\ .$$

The relevant transformation is then

$$g = \frac{-2a_u}{1 + a_u c_u}, \text{ with } c_u = \frac{2m_K}{m_{\pi^+}^2}\,\Delta = 0.2272.$$

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

$$c_v = \frac{m_{\pi^+}^2}{2m_K^2} = 0.0393$$

and $d_v = \dfrac{Q}{3m_K}\,(1 + \Delta) = 0.0604.$

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                 10  CHARGED K ENERGY DEPENDENCE OF DALITZ PLOT

        RELATED TEXT SECTION IV F.1, APPENDIX I, AND MINI-REVIEW ABOVE

       MATRIX ELEMENT SQUARED =  1 + G (S3-SO)/(MPI+**2)

GT+  LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS  K+ INTO PI+ PI+ PI-
GT+     THESE EXPTS FIT M**2=1+AY*Y. WE LIST G IN THE MAIN LISTING AND
GT+     GIVE AY AT RIGHT. G=-1.5*AY*(MPI**2)/(MK*Q). SEE NOTE ABOVE.
GT+Z  5428   -0.22     0.024          ZINCHENKO 67 HBC  +  AY=0.28+-.03      10/69
GT+   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+Q  750K   -0.2158   0.0028         FORD      72 ASPK +  AY=0.2734+-.0035  4/72*
GT+  39819   -0.201    0.008          HOFFMASTE 72 HLBC +  INCLUDES GRAUMAN  1/71
GT+ Q   THIS VALUE OF AY IS FROM A QUADRATIC FIT WITH Y**2 COEF=.030+-.010.  4/72*
GT+ Q   A LINEAR FIT IS QUOTED ONLY FOR THEIR COMBINED K+ AND K- SAMPLE.     4/72*
GT+ Q   IT GIVES AY=0.2737+-.0032 .  THE QUADRATIC FIT TO THE COMBINED       4/72*
GT+ Q   SAMPLE GIVES AY=0.2752+-.0033 AND Y**2 COEFF=0.025+-.010 .           4/72*
GT+ Q   (CHISQ/DF)=1.38 FOR LINEAR FIT AND 1.20 FOR QUADRATIC FIT.           1/73*
GT+ G   EMULS. DATA ADDED - ALL EVENTS INCLUDED BY HOFFMASTER 72             1/71
GT+ Z   ALSO INCLUDES DBC EVENTS.
GT+          . . . . . . . . .
GT+ AVG      -0.2144   0.0045  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                               (SEE IDEOGRAM BELOW )
```
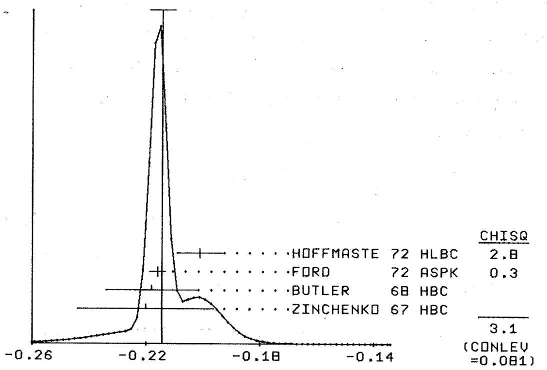
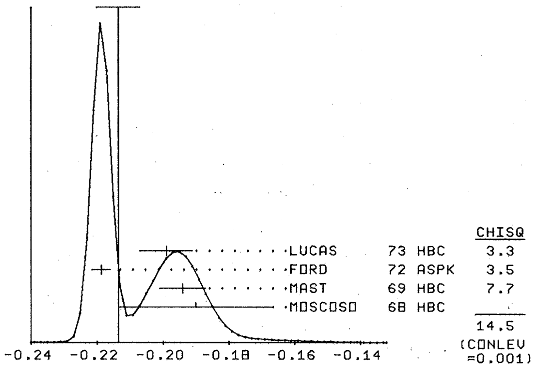

WEIGHTED AVERAGE = -0.2144 ± 0.0045
ERROR SCALED BY 1.7



LIN. ENERGY DEP. FOR K+ TO PI+ PI+ PI-

```
GT-  LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS  K- INTO PI- PI- PI+
GT-     FOR DEFINITION OF AY SEE NOTE UNDER S10GT+.
GT- F 1347  (-0.220)  (0.035)         FERRO-LUZ 61 HBC  - AY=0.28+-.045     10/69
GT-M  5778   -0.190    0.023          MOSCOSO   68 HBC  - AY=0.242+-.029    10/69
GT-  50919   -0.194    0.007          MAST      69 HBC  - AY=0.247+-.009    10/69
GT-Q  750K   -0.2187   0.0028         FORD      72 ASPK - AY=0.2770+-.0035  4/72*
GT-    84K   -0.199    0.008          LUCAS     73 HBC  - AY=0.252+-.011   10/72*
GT- Q   THIS VALUE OF AY IS FROM A QUADRATIC FIT WITH Y**2 COEF=.020+-.010.  4/72*
GT- Q   SEE ALSO THE NOTE Q IN THE GT+ SECTION ABOVE.                        4/72*
GT- F   NO RADIATIVE CORRECTIONS INCLUDED.
GT- M   ALSO INCLUDES DBC EVENTS.
GT-          . . . . . . . . .
GT- AVG      -0.2135   0.0066  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7)
                               (SEE IDEOGRAM BELOW )
```

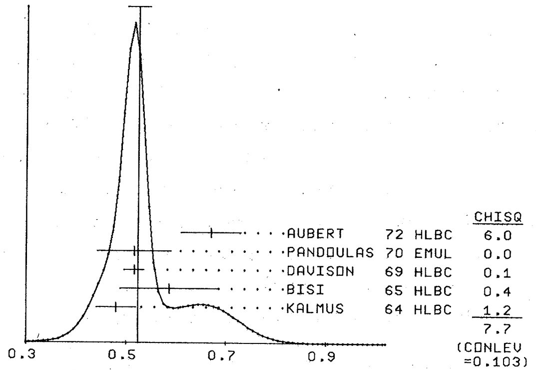
WEIGHTED AVERAGE = -0.2135 ± 0.0066
ERROR SCALED BY 2.7



LIN. ENERGY DEP. FOR K- TO PI- PI- PI+

```
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 ENERGY DEPENDENCE (G) FOR TAU PRIME DECAY CHA.K INTO PI PIOPIO
GTP   1792     0.48     0.04          KALMUS     64 HLBC +                   10/69
GTP   1874     0.586    0.098         BISI       65 HLBC +  ALSO HBC         10/69
GTP   4048     0.516    0.020         DAVISON    69 HLBC +  ALSO EMUL        10/69
GTP    198     0.516    0.074         PANDOULAS  70 EMUL +                   10/70
GTP  A1365     0.67     0.06          AUBERT     72 HLBC                      1/73*
GTP  A  WE GIVE LINEAR TERM OF HIGHER ORDER FIT. EQ.I OF APP.II,AUBERT 72.    1/73*
GTP          . . . . . . . . .
GTP AVG        0.523    0.023   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                                (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.523 ± 0.023
ERROR SCALED BY 1.4



LIN. ENERGY DEP. FOR K TO PI PIO PIO

Note on K^+ and K^0 Form Factors

The definitions of the parameters λ_+, λ_-, and ξ can be found in Section IV F. 2 of the text. Many approximations are usually made to extract these or related parameters from the experimental data.

1) Scalar and tensor currents: there is no evidence for scalar or tensor currents, so pure vector current is usually assumed.

2) Im ξ so far is consistent with 0, and this is usually assumed in most of the experiments.

3) Radiative corrections are not serious; they change λ_+ by about 0.005 (GINSBERG 67 and 70).

4) Older $K_{\mu 3}$ experiments have determined ξ assuming $\lambda_+ = \lambda_0 = 0$.

5) Momentum transfer dependence of ξ: many $K_{\mu 3}$ experiments have determined ξ assuming a linear q^2 dependence for f_+, as in Eq. (27) of the main text. Some of these assume $\lambda_- = 0$ since there is no strong evidence for a non-zero λ_-. Others allow $\lambda_- \neq 0$ or equivalently $\Lambda \neq 0$ where

$$\xi(q^2) = \xi(0) + \Lambda \frac{q^2}{m_\pi^2} .$$

Instead of λ_- or Λ, HAIDT 71 (K^+) gives $\xi(q^2)$ where q^2 is chosen to minimize the correlation with $\xi(0)$.

6) Most K_{e3} experiments have assumed a linear q^2 dependence for f_+.

Since it is now clear that $\lambda_+ \neq 0$, assumption-4 values of ξ are parenthesized. Assumption-5 values of ξ and λ_+ are encoded and any corresponding non-zero values of λ_- or Λ are given in footnotes. No attempt is made to average these ξ or λ_+ values because they are highly correlated.[1,2] As in the past, we keep the values of ξ as obtained in the μ polarization measurements (ξ_B) separated from the values obtained from branching ratios and spectra (ξ_A).

Assumption-6 values of λ_+ (for K_{e3}) are encoded and averaged. There is some indication from CHIEN 71 (K^0_L) that a quadratic q^2 term may be required in f_+ for K_{e3}. Chounet, Gaillard, and Gaillard[2] further suggest that the large values of λ_+ in $K^0_{\mu 3}$ (compared with K^0_{e3}) could be explained by the presence of a second order term.

See references 1 and 2 for excellent reviews of $K_{\ell 3}$ form factors and for a thorough treatment of the problems of correlations, higher order terms, and alternative parametrizations.

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).

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                    10  CHARGED K FORM FACTORS                           8/67

        RELATED TEXT SECTION IV F.2 AND MINI-REVIEW ABOVE

          F+ AND F- ARE FORM FACTORS FOR THE VECTOR MATRIX ELEMENT
          FS AND FT REFER TO THE SCALAR AND TENSOR TERM

XIA     XIA = F-/F+ (DETERMINED FROM SPECTRA AND KMU3/KE3)   ---------------
XIA      SOME OF THE OLDER EXPERIMENTS HAVE EVALUATED XI ASSUMING THAT IT IS
XIA      INDEPENDENT OF THE MOMENTUM TRANSFER (T), I.E., THEY SET L+=L-=0.
XIA      OTHERS HAVE ASSUMED A VALUE FOR L+ AND USED L-=0. ONLY RECENTLY
XIA      BOTH L+,L- AND XI(0) (OR THREE RELATED PARAMETERS) HAVE BEEN INCLU-
XIA      DED IN THE FITS . SEE HAIDT 71. (OR CHIEN 70 FOR KOL) .
```

```
XIA L   76  (+1.8)    (1.6)            BROWN      62 XEBC +  MU+,PIO SPECTRA    8/67
XIA L   87  (+0.7)    (0.5)            GIACOMELL  64 EMUL +  MU+ SPECTRUM       8/67
XIA L       (-0.1)    (0.7)            JENSEN     64 XEBC +  MU+,PIO SPECTRN    8/67
XIA L       (-0.17)   (0.75)   (0.99)  SHAKLEE    64 XEBC +  KMU3/KE3           8/67
XIA L       (+0.6)    (0.5)            BISI 1     65 HBC  +  KMU3/KE3           8/67
XIA        BTWN +0.2 AND +1.4          CUTTS      65 OSPK +  MU+ SPECTRUM       8/67
XIA L 1509  (+0.4)    (0.4)            CALLAHA1   66 FRBC +  KMU3/KE3           8/67
XIA   2648    0.0      1.1       0.9   CALLAHA1   66 FRBC +  MU+ SPECTRUM       8/67
XIA    444   +0.72     0.80            CALLAHA1   66 FRBC +  P+0 SPEC,FIX MU    8/67
XIA L       (+0.75)   (0.50)           AUERBACH   67 OSPK +  KMU3/KE3           8/67
XIA E 1398  (-0.60)   (0.20)           EICHTEN    68 HLBC +  KMU3/KE3 T=4.     10/68
XIA B 5601  (-0.08)   (0.15)           BOTTERIL2  68 ASPK +  KM3/KE3, L+=.023   6/68
XIA L   78  (-0.5)    (0.9)            EISLER     68 HLBC +  PIO SPECT, L+-=0   6/68
XIA L  976  (+1.0)    (0.6)            GARLAND    68 OSPK +  KMU3/KE3, L+-=0    4/68
XIA           0.91     0.82            ZELLER     69 ASPK +  KM3/KE3, L+=0.23  10/69
XIA  B       -0.35     0.22            BOTTERIL   70 OSPK    KM3/KE3, L+=.045  10/69
XIA  H3240   -0.80     0.50            HAIDT      71 HLBC +  D.P. L+=.055,T=7   2/72
XIA   3240   -0.50     1.5             HAIDT      71 HLBC +  D.P. L+=.055,T=0   2/71
XIA   1505   -0.72     0.21            HAIDT      71 HLBC +  KM3/KE3 NOTE K     2/71
XIA   4025   -0.62     0.28            ANKENBRAN  72 ASPK +  PIO  L+=.024 T=0   6/72*
XIA   3480   -0.09     0.28            CHIANG     72 OSPK +  D.P. L+-=.029T=0   9/72*
XIA L   L+ AND  L-  ASSUMED TO BE ZERO.
XIA E   EICHTEN 68 REPLACED BY HAIDT 71.
XIA  E  T=4  ASSUMES  L+=.023+-.008 - INSENSITIVE TO L-.
XIA  B  T=0  BOTTERIL 70 IS REEVALUATION OF BOTTERIL2 68 WITH DIFF. L+.      10/69
XIA  H  HAIDT 71 T=6.8 VALUE CORRECTED USING FIGURE 18B.                      2/72
XIA  H  VALUES AT T=0 AND AT T=6.8 ARE UNCORRELATED.                          2/72
XIA  K  T=3.9  HAIDT 71 KM3/KE3 VALUE ASSUMES L+=.029 - INDEPENDENT OF L-.    1/73*
XIA          . . . . . . . . .
XIA AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

XIB     XIB = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)   ------------
XIB      THE MU POLARIZATION IS A MEASURE OF XI(T). NO ASSUMPTIONS ON L+-
XIB      NECESSARY, T SHOULD BE SPECIFIED.
XIB   2100   +1.2      2.4      1.8   BORREANI   65 HLBC +  POLARIZATION       8/67
XIB    397   -1.4      1.8            CALLAHA1   66 FRBC +  TOTAL POLA-.       8/67
XIB   2950   -0.7      0.9      3.3   CALLAHA1   66 FRBC +  LONG. POLAR.       8/67
XIB   3133   -0.95     0.3            CUTTS      68 OSPK +  TOTAL POL. T=3     6/68
XIB  H6000   -0.6      1.1            HAIDT      71 HLBC +  TOTAL POL. T=0     2/72
XIB  H6000   -1.0      0.3            HAIDT      71 HLBC +  TOTAL POL. T=4.9   2/72
XIB  H  HAIDT 71 VALUES AT T=0 AND T=4.9 ARE UNCORRELATED.
XIB          . . . . . . . . .
XIB AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

IXI         IMAGINARY PART OF XI (TEST OF T REVERSAL)   ------------------
IXI            0.1       0.4       0.3   BETTELS    68 HLBC     POLARIZATION      10/69

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*

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*

L+E     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KE3 DECAY)   ---------
L+E     FOR RAD. CORR. TO THE DALITZ PLOT, SEE GINSBERG 67.
L+E    217   +0.036     .045              BROWN      62 XEBC +  PIO SPEC,NO R.C.
L+E    407   -0.010     .029              JENSEN     64 XEBC +  PIO SPEC,NO R.C.   8/67
L+E    230   -0.04      .05               BORREANI   64 HBC  +  E+ SPEC,NO R.C.    8/67
L+E    854    0.045    0.017     0.018    BELLOTT2   67 FBC  +  DLTZ PLT, R.C.    11/67
L+E   1393   +0.016     .016              IMLAY      67 OSPK + DLTZ PLT,NO R.C.    8/67
L+E    515   +0.028     .013      .014    KALMUS     67 FBC  + E,PI SPEC,NO R.C.   8/67
L+E    960   (.08)     (.04)              BOTTERIL1  68 ASPK + E SPEC  USES R.C.   6/68
L+E     90   -0.02     0.08      0.12     EISLER     68 HLBC + PIO SPEC,NO R.C.    6/68
L+E   1458    .045      .015              BOTTERIL   70 OSPK    PIO SPECTRUM RC   10/69
L+E   2707   0.027     0.010              STEINER    71 HLBC DLTZ PLT,USES R.C.   11/71
L+E   4017   0.029     0.011              CHIANG     72 OSPK +  DLTZ PLOT,NO RC    9/72*
L+E          . . . . . . . . .
L+E AVG      0.0282    0.0052   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

L+M     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KMU3 DECAY)
L+M      FOR RAD. CORR. TO DALITZ PLOT OF KMU3  SEE GINSBERG 70
L+M    3240   0.055     0.025             HAIDT      71 HLBC    KMU3 DAL. PLOT     2/71
L+M    4025   0.024     0.022             ANKENBRAN  72 ASPK +  PIO SPEC XI=-.62   6/72*
L+M          . . . . . . . . .
L+M AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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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.CONS.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       BISI,MARZARI-CHIESA,RINAUDO          (TORINO)
BORREANI 65 PR 140 B1686        BORREANI,GIDAL,RINAUDO,CAFORIO+ (BARI,TORI)
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Stable Particles
$K^{\pm}$, K^0, K^0_S

Data Card Listings
For notation, see key at front of Listings.

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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)

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)
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)
BELLOTT1 67 HEIDELBERG CONF    BELLOTTI,PULLIA                       (MILAN)
BELLOTT2 67 NC 52A  1287       BELLOTTI,FIORINI,PULLIA               (MILAN)
    ALSO 66 PL  20  690        BELLOTTI,F+ORINI,PULL+A+              (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)

CLINE    67 HEIDELBERG CONF    CLINE,HAGGERTY,SINGLETON,FRY+     (WISCONSIN)
FLETCHER 67 PRL  19  98        FLETCHER,BEIER,EDWRADS,+           (ILLINOIS)
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+
BOTTERIL 68 PR 171 1402        BOTTERILL,BROWN,CORBETT,CULLIGAN+  (OXFORD)
BOTTERI1 68 PR 174 1661        BOTTERILL,BROWN,CLEGG,CORBETT,+    (OXFORD)
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)
CUTTS    68 PRL 20 955         CUTTS,STIENING,WIEGAND,DEUTSCH    (LRL,MIT)
    ALSO 65 PR 138 B969        CUTTS,ELIOFF,STIENING                   (LRL)
    ALSO 69 PR 184 1380        +STIENING,WIEGAND,DEUTSCH         (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)

CAMERINI 69 PRL 23 326         +LJUNG,SHEAFF,CLINE                (WISCONSIN)
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)
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+        (OXF)
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)
PANDOULA 70 PR D2 1205         +TAYLOR,KOLLER,GRAUMAN +        (STEV,SETO)

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,STEINING             (CHIC,LRL)
    ALSO 70 PRL 24 1086        KLEMS,HILDEBRAND,STEINING        (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+NAL+YALE)
AUBERT   72 NC 12A 509         +HEUSSE,PASCAUD,VIALLE+    (ORSA+BRUX+EPOL)
BEIER    72 PRL 29 678         +BUCHHOLZ,MANN,PARKER        (PENNSYLVANIA)
CABLE    72 PL 40B 699         +HILDEBRAND,PANG,STEINING         (EFI,LBL)
CHIANG   72 PR D6 1254         +ROSEN,SHAPIRO,HANDLER,OLSEN+   (ROCH+WISC)
CLARK    72 PRL 29 1274        +CORK,ELIOFF,KERTH,MCREYNOLDS,NEWTON+ (LBL)
CLINE    72 PRL 28 1287        D CLINE, D LJUNG                (WISCONSIN)
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)
LJUNG    72 PRL 28 523         D LJUNG                          (WISCONSIN)

BACKENST 73 TO BE PUB.IN PL B BACKENSTOSS,BAMBERGER+(CERN,KARL,HEID,STOH)
LUCAS    73 PR TO BE PUBL.     P W LUCAS,H D TAFT,W J WILLIS         (YALE)

         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,TORI)
FEARING  70 PR D3 542          +FISCHBACK,SMITH                  (STON+BOHR)
GINSBERG 70 PR D1 229          E S GINSBERG                      (IIT HAIFA)

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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    FIT   497.71     0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  1/73*
               WEIGHTED AVERAGE = 497.87 ± 0.32
                    ERROR SCALED BY 1.5
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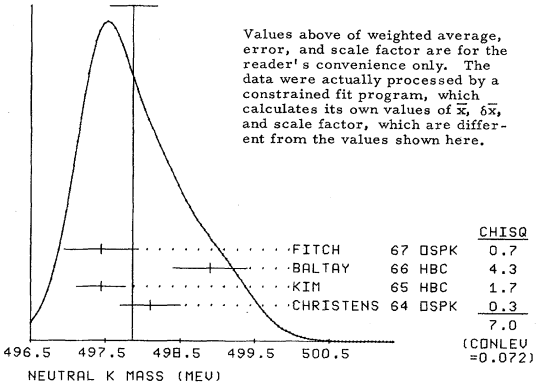

Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\overline{x}$, $\delta\overline{x}$, and scale factor, which are different from the values shown here.

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               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   FIT     3.99     0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  1/73*
****** ********* ********* ********* ********* ********* ********* ********

                          REFERENCES FOR NEUTRAL K

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)
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,ROBINSON,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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Note on the K^0_S Mean Life

In a bubble chamber experiment SKJEGGESTAD 72 obtain a value for the K^0_S mean life, τ_S = $(0.8958 \pm 0.0045) \times 10^{-10}$ sec, which is significantly higher than the combined results of previous experiments [$(0.862 \pm 0.006) \times 10^{-10}$ sec from our 1972 edition]. In addition, the CERN-Heidelberg Collaboration (in a vacuum regeneration experiment) reported a preliminary value $(0.899 \pm 0.005) \times 10^{-10}$ sec (Batavia 1972) in agreement with SKEGGESTAD. However, it should be pointed out that the CERN-Heidelberg number is highly correlated with $|\eta_{+-}|$ for which they find a value of $(2.35 \pm .07) \times 10^{-3}$.

We have not entered the CERN-Heidelberg results in our listings because they have not been published yet.

The corrections for systematic biases in SKJEGGESTAD 72 and in HILL 68 (updated) amount to +1% and 0.7% respectively. Similar corrections, if applied to the older bubble chamber results, would probably increase their average by only about one standard deviation and would not account for the discrepancy. We therefore retain all results in the average, $\tau_S = (0.882 \pm 0.008) \times 10^{-10}$ sec, where we have increased the error by a scale factor of 2.5 because of the disagreement.

Because of the uncertain future of τ_S, we have not attempted to adjust the K_L^0-K_S^0 mass difference, ϕ_{+-} or ϕ_{00} values. The fitted K_S^0 rates, $|\eta_{+-}|$, and $|\eta_{00}|$ are automatically adjusted to our new τ_S value by our fitting procedure.

To show how $\Delta m(K_L^0-K_S^0)$ and ϕ_{+-} are affected by our new τ_S, we use the correlation given by ARONSON 70 (K_L^0) between $\Delta m(K_L^0-K_S^0)$ and τ_S, which indicates that a change in τ_S from 0.862 to 0.882 increases their value of Δm by about .006 x 10^{10} sec^{-1}. A change in Δm of this amount would lead to an increase in ϕ_{+-} of about 3.5°, using the Δm dependence of JENSEN 70, which is the most precise measurement of ϕ_{+-}. (See the F_{+-} section in the K_L^0 Data Card Listings.)

```
                     12  KOS MEAN LIFE (UNITS 10**-10 SEC)
T        KOS MEAN LIFE
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   O   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  H   50K    0.8958   0.0045         SKJEGGEST  72 HBC               1/73*
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          . . . . . . . . .
T   AVG       0.8824   0.0092   0.0091 AVERAGE (ERROR INCL. SCALE FACTOR OF 2.7)
T   FIT       0.8824   0.0082 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.5)
                       (SEE IDEOGRAM BELOW )

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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

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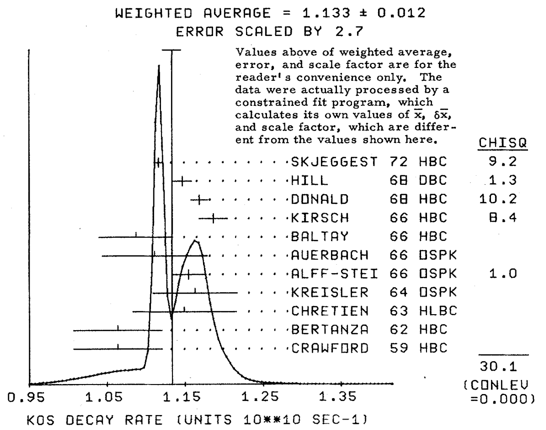

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```
                  12  KOS BRANCHING RATIOS

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  1648    0.684     0.011           DOYLE     69 HBC      PI-P TO LAM.KO    2/71
R1  U   ANDERSON RESULT NOT PUBLISHED, EVENTS ADDED TO DOYLE SAMPLE             2/71
R1          . . . . . . . . .
R1  AVG       0.684     0.011   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  FIT       0.6881    0.0029 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  FIT       0.3119    0.0029 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                        (SEE IDEOGRAM BELOW )
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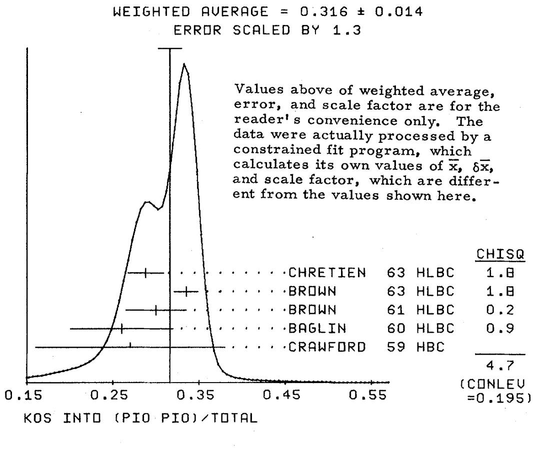

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```
R3     KOS INTO (PI+ PI-)/(PIO PIO)                          (P1)/(P2)
R3  G 3016   (2.285)  (0.055)        GOBBI     69 OSPK    K+N TO KOP         5/69
R3    3700    2.10     0.06          MORFIN    69 HLBC    K+N TO KOP        10/69
R3 G  7944    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     701    2.10     0.11          NAGY      72 HLBC    K+N TO KOP         1/73*
R3 A    THE DIRECTLY MEASURED QUANTITY IS KOS TO PI+ PI-/ALL KO=.345+-.005   6/72*
R3 B    THE DIRECTLY MEASURED QUANTITY IS KS TO PI+PI-/ALL KOBAR=.345+-.005 12/71
R3 G    MOFFETT 70 IS A FINAL RESULT WHICH INCLUDES GOBBI 69.                2/72
R3          . . . . . . . . .
R3  AVG       2.212    0.034    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R3  FIT       2.207    0.029   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                       (SEE IDEOGRAM BELOW )
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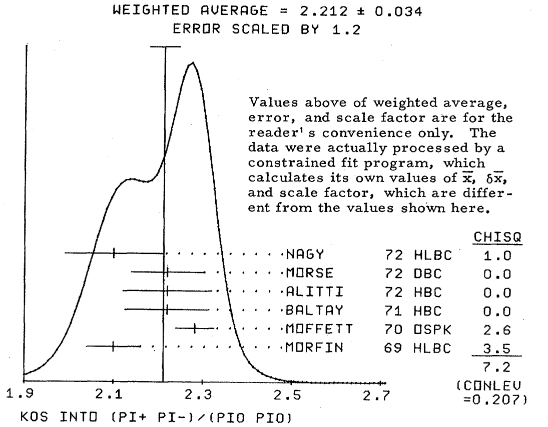

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```
R4      (KOS INTO PI+ PI- PIO, CP VIOLATING)/(KOL INTO PI+ PI- PIO)
R4       TEST OF CP VIOLATION - SEE TEXT SECTION IV F.3A FOR DEFINITIONS
R4       CPT ASSUMED VALID - (I.E. RE(A)=0) - ONLY (IMA)**2 QUOTED HERE
R4       18   (3.8)  OR LESS  CL=.90   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  M    50   (1.2)  OR LESS  CL=.95   MEISNER   71 HBC    CL=.9 NOT AVAIL.  2/71
R4      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     0.27  OR LESS  CL=.90   METCALF   72 ASPK                 11/72*
R4  M    THESE AUTHORS FIND REAL(A)= 2.75+-.65, ABOVE VALUE AT RE(A)=0      2/71
R4 C     THIS IS THE COMBINED RESULT OF ANDERSON 65 AND WEBBER 70

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   S   VALUE CALCULATED BY US, USING 2.3 INSTEAD OF U 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

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 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*

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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)

BOTT-BOD 67 PL 24B 194         BOTT-BODENHAUSEN,DE BOUARD,CASSEL+   (CERN)
DONALD   68 PL 27B  58         DONALD,EDWARDS,NISAR+ (LIVP,CERN,IPNP,CDEF)
HILL     68 PR 171 1418        HILL,ROBINSON,SAKITT +       (BNL,CARNEGIE)

BANNER   69 PR 188 2033        +CRONIN,LIU,PILCHER              (PRINCETON)
BOHM     69 THESIS             A. BOHM                               (AACH)
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(ILLINOIS)

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+ (COLU)
    ALSO 71 NEVIS-187 THESIS   WILLIAM A. COOPER                 (COLUMBIA)
CHO      71 PR D3 1557         +DRALLE,CANTER,ENGLER,FISK+ (CARN+BNL+CASE)
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)
    ALSO 71 PL 35B 265         JAMES,MONTANET,PAUL,PAULI+ (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         +NAUENBERG,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)

                               PAPERS NOT REFERRED TO IN DATA CARDS

BIRGE    60 ROCH CONF 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 CONF 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 FROM 1965 ARGONNE CONF., PAGE 115.
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K_L^0 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  T        (2.20)   (0.35)             FITCH     61 CNTR
* D            0.84     0.29     0.22 GOOD      61 HLBC
* D  T         1.02     0.23              CAMERINI  62 HLBC    SEE NOTE C BELOW  8/67
  D   C  VALUE CHANGED FROM 1.7 (SEE TABLE 1 OF CAMERINI 66)                    8/67
  D  T         0.55     0.24              AUBERT    65 HLBC                     6/66
  D            0.26     0.36     0.26 BALDO-CEO 65 HLBC    ASSUMES CP CONS.
  D  T A       0.64     0.12              CHRISTENS 65 OSPK                     6/66
  D   A CHRISTENSON 65 HAS BEEN CORRECTED FOR INTERFERENCE BY FITCH 65 FTNOT  1/71
  D  T        (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   V  VISHNEVSKY 65 NOT CORRECTED FOR INTERFERENCE EFFECTS                  3/68
  D            0.514    0.039             ALFF-STEI 66 OSPK                     6/66
  D       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  T    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   N   ERROR IGNORES UNCERTAINTY OF PHASE SHIFTS.  THESE EVENTS ARE         10/71
  D   N   USED IN HILL 71.
  D       95   0.62     0.10     0.16 CHANG     66 HBC     KO+P INTO HYPER.  8/67
  D            0.81     0.17              FUJII     66 OSPK    IRON REGENERATOR  9/66
  D       59   0.74     0.34              MEISNER1  66 HBC     SEE NOTE M1       6/66
  D   M1     + SIGN FAVORED               MEISNER2  66 HBC                       9/66
  D            0.38     0.16              JOVANOVIC 66 OSPK    C+URANIUM REGEN. 11/66
* D  T   136 + 0.64     0.19              CANTER    67 DBC     KO+D INTO HYPER. 11/67
  D            0.65     0.11              MISCHKE   67 OSPK                    .11/67
  D      590   0.59     0.13              BALATZ    68 OSPK    AL REGENERATOR    3/68
  D            0.520    0.044             CARNEGIE  68 HBC     GAP METHOD        3/68
  D  T        +0.487    0.046             MELHOP    68 OSPK    ST.STEEL REGEN    6/68
* D  B         0.547    0.024             BOTT-BOD  69 OSPK    C REGEN           1/71
  D  B   BOTT-BOD 69 IS A REEVALUATION OF BOTT-BOD 66                          1/71
  D  F         0.555    0.020             FAISSNER  69 ASPK    REGEN IN CU      10/69
  D  F   ESTIMATED ADDITIONAL SYSTEMATIC UNCERTAINTY LESS THAN TWO PERCENT     1/71
  D            0.542    0.006             CULLEN    70 CNTR                     1/71
  D            0.542    0.006             ARONSON   70 ASPK    GAP METHOD        1/71
  D            0.481    0.052    0.075 BALATS    71 OSPK                     9/71
  D            0.534    0.007             CARNEGIE  71 ASPK    GAP METHOD        8/71
  D  TH  119 (+ 0.67)  (0.14)             HILL      71 DBC                     10/71
  D   H   THE PRIMARY RESULT OF THIS EXPERIMENT IS THAT DM IS POSITIVE.        10/71
  D   H   THE MAGNITUDE MAY HAVE AN ADDITIONAL SYSTEMATIC ERROR OF ABOUT 0.12 10/71
  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           . . . . . . . . .
  D   AVG      0.5402   0.0035   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)


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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   FIT        5.181     0.041   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

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                 NEUTRAL K CONSTRAINED FIT
           OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING
           RATIOS USES 62 DATA POINTS TO DETERMINE SIX
           QUANTITITES.  OVERALL FIT HAS CHISQ=56.5.

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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 5         P11
 P 1 .2151+-.0079
 P 2   -.2656  .1257+-.0027
 P 3   -.4833     -.0695  .2691+-.0059
 P 4   -.5850     -.0638     -.3326  .3876+-.0065
 P 5   -.2849      .0431      .1412      .1702  .0016+-.0001
 P11    .1531     -.0508     -.0862     -.1044     -.0511  .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 .0415+-.0016
 G 2   -.1448  .0243+-.0005
 G 3   -.3444      .0341  .0519+-.0012
 G 4   -.4047      .0572     -.1801  .0748+-.0013
 G 5   -.2032      .1036      .1950      .2298  .0003+-.0000
 G11    .1617     -.0300     -.0638     -.0751     -.0379  .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        4.15      0.16    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

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       50     2.12      0.33              MEISNER    71 HBC     ASSUMES CP       10/71
W2      180     2.35      0.20              JAMES      72 HBC     ASSUMES CP        1/73*
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              . . . . . . . . . .
W2   AVG        2.36      0.15     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
W2   FIT        2.425     0.054   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
                          (SEE IDEOGRAM BELOW )

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   FIT        7.48      0.13    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       15.10      0.18    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   FIT       12.68      0.16    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                          (SEE IDEOGRAM BELOW )
```
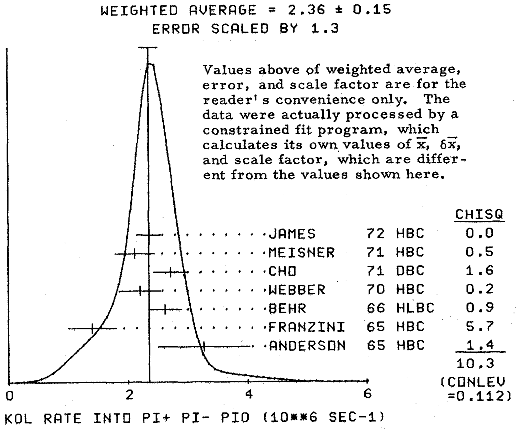
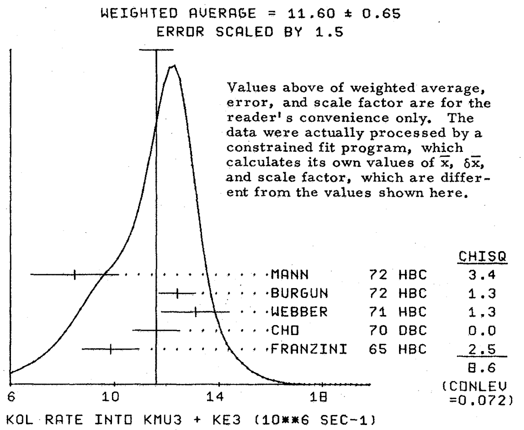



Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\overline{x}$, $\delta\overline{x}$, and scale factor, which are different from the values shown here.



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.

```
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        5.19      0.12    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   FIT        0.275     0.013   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      558     0.159     0.010             EVANS      73 HLBC                      1/73*
R2              . . . . . . . . . .
R2   AVG        0.1615    0.0038   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2   FIT        0.1606    0.0034 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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        0.3440    0.0066 FROM FIT

R4      KOL INTO (PI E NEUTRINO)/CHARGED                  (P4)/(P2+P3+P4)
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        0.488     0.033    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4   FIT        0.4954    0.0067 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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Stable Particles
K_L^0

Data Card Listings
For notation, see key at front of Listings.

```
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      0.5902    0.0077 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6     KOL INTO (PI+ PI- PIO)/TOTAL                      (P2)
R6
R6           . . . . . . . . .
R6  FIT      0.1257    0.0027 FROM FIT

R7     KOL INTO (LEPTON PI NEUTRINO)/TOTAL               (P3+P4)
R7
R7           . . . . . . . . .
R7  FIT      0.6568    0.0072 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)

R9     KOL INTO (PI+ PI-)/CHARGED (UNIT 10**-3)          (P5)/(P2+P3+P4)
R9      45   2.0       0.4           CHRISTENS 64 OSPK ETA +- = 1.94
R9      54   2.08      0.35          GALBRAITH 65 OSPK ETA +- = 2.02
R9           1.93      0.26          BASILE    66 OSPK ETA +- = 1.86     . 9/66
R9           1.993     0.080         BOTT-BODE 66 OSPK ETA +- = 1.935      9/66
R9           . . . . . . . . .
R9  AVG      1.992     0.073  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R9  FIT      2.001     0.063 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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          0.67      0.13          KULYUKINA 68 CC                       2/71
R10 B        (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   1309   0.662     0.030         EVANS     73 HLBC                     1/73*
R10 B  BEILLIERE 69 IS A SCANNING EXPT USING SAME EXPOSURE AS BUDAGOV 68
R10          . . . . . . . . .
R10 AVG      0.695     0.022  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R10 FIT      0.694     0.022 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

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

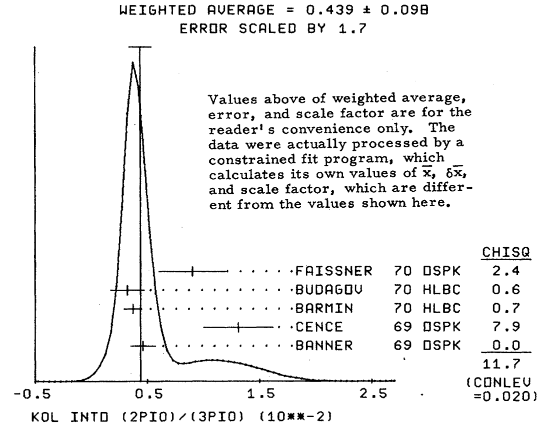
R15    KOL INTO (E+ PI- NEU)/(E- PI+ NEU)
R15 O   97   (0.90)    (0.18)        NEAGU     61 CC
R15 O        (1.01)    (0.16)        LUERS     64 HBC                      8/66
R15 O  894   (0.99)    (0.023)       KULYUKINA 66 CC                       9/66
R15 O 1539   (1.06)    (0.05)        VERHEY    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 70 R19          1/71
R17          . . . . . . . . .
R17 FIT      0.94      0.19   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          . . . . . . . . .
R18 AVG      1.81      0.13   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R18 FIT      1.711     0.081 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    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  F FAISSNER 70 CONTAINS SAME 2PIO EVENTS AS GAILLARD 69 R17
R19          . . . . . . . . .
R19 AVG      0.439     0.098  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R19 FIT      0.44      0.29  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 5.1)
                       (SEE IDEOGRAM BELOW )
```



WEIGHTED AVERAGE = 0.439 ± 0.098
ERROR SCALED BY 1.7

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.

```
R20    KOL INTO (PI+ PI-)/(KE3 + KMU3) (UNITS 10**-3)    (P5)/(P3+P4)
R20    309   2.51      0.23          DEBOUARD  67 OSPK                     6/68
R20    525   2.35      0.19          FITCH     67 OSPK   ETA+-=1.91+-.06   6/68
R20          . . . . . . . . .
R20 AVG      2.41      0.15   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R20 FIT      2.384     0.076 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 CONF 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)
```

Note on the $K_L^0 \to \mu^+\mu^-$ Controversy

The $K_L^0 \to \mu^+\mu^-$ branching ratios (R22) given by CLARK 71 and CARITHERS 73 are incompatible. We therefore make no attempt to combine their results.

CARITHERS 73 is a preliminary result based on their reported observation of 6 events. They are continuing data-taking and analysis.

CLARK 71 observe no events but would expect around 12 based on the CARITHERS 73 rate. CLARK 71 are rechecking their analysis but have found nothing which could account for the loss of these events (A. Clark, private communication).

The discrepancy is interesting on theoretical grounds because the CLARK 71 result is below the "unitarity" lower limit for this decay.

```
R22    KOL INTO (MU+MU-)/(PI+PI-) (UNITS 10**-5)         (P6)/(P5)
R22      0   14.0  OR LESS  CL=.90   FOETH     69 ASPK                     5/70
R22      0   1.8   OR LESS  CL=.90   DARRIULAT 70 ASPK                    11/70
R22      0   0.12  OR LESS  CL=.90   CLARK     71 ASPK                     6/71
R22 C    6   (0.6)                   CARITHERS 73 ASPK   PRELIMINARY       1/73*
R22 C   CARITHERS 72 GIVES K3L TO MU+MU-/ALL=9*10**-9. WE CONVERT TO R22.  1/73*

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

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Data Card Listings
For notation, see key at front of Listings.

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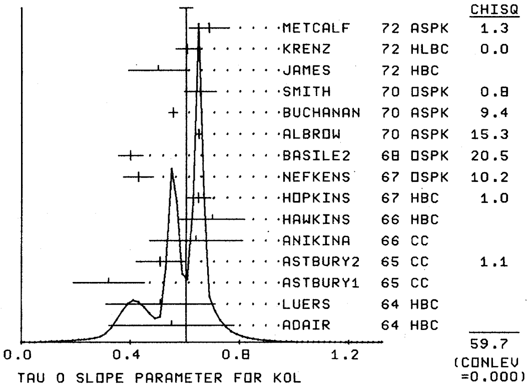
                   13  KOL ENERGY DEPENDENCE OF DALITZ PLOT

        RELATED TEXT SECTION IV F.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 (S3-S0)/(MPI+**2)

GTO  LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS  KLONG INTO PI+ PI- PIO
GTO     79     0.55      0.23            ADAIR       64 HBC  AV=-7.6 +- 1.7       . 3/71
GTO     77     0.51      0.20            LUERS       64 HBC  AV=-7.3 +- 1.6         3/71
GTO     66     0.32      0.13            ASTBURY1    65 CC   AV=-5.5 +- 1.5         3/71
GTO    310     0.51      0.09            ASTBURY2    65 CC   AV=-(7.3 +.6 -.8)      3/71
GTO    280     0.64      0.17            ANIKINA     66 CC   AV=-(8.2 +.9 -1.3)     3/71
GTO    126     0.70      0.12            HAWKINS     66 HBC  AV=-8.6 +- 0.7         3/71
GTO   1350     0.649     0.044           HOPKINS     67 HBC  AT=-0.294 +- .018     10/69
GTO   1198     0.428     0.055           NEFKENS     67 OSPK AU=-0.204 +- .025      3/71
GTO   2446     0.400     0.045           BASILE2     68 OSPK AT=-0.188 +- .020      3/71
GTO  29000     0.651     0.012           ALBROW      70 ASPK AY=-0.862 +- .015      1/71
GTO  B 36K     0.555     0.016           BUCHANAN    70 ASPK AU=-0.261 +- .007      3/71
GTO   4400     0.656     0.058           SMITH       70 OSPK AT=-0.297 +- .024      3/71
GTO    180     0.50      0.11            JAMES       72 HBC                         1/73*
GTO   1486     0.608     0.043           KRENZ       72 HLBC AT=-0.277 +- .018     11/72*
GTO    384     0.688     0.074           METCALF     72 ASPK AT=-0.31  +- .03      11/72*
GTO  B  BUCHANAN 70 GIVES A=0.257 +- .005 FOR A QUADRATIC FIT WITH                  3/71
GTO  B  STATISTICAL ERRORS ONLY.  THE A VALUE USED HERE IS FOR A LINEAR             3/71
GTO  B  FIT AND INCLUDES SYSTEMATIC ERRORS. QUADRATIC FIT DOES NOT                  1/73*
GTO  B  IMPROVE CHI SQUARED PROBABILITY.                                            1/73*
GTO          . . . . . . . . . .
GTO AVG        0.604     0.023    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7)
                                  (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.604 ± 0.023
ERROR SCALED BY 2.7



TAU 0 SLOPE PARAMETER FOR KOL

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                   13  KOL FORM FACTORS

        RELATED TEXT SECTION IV F.2 AND MINI-REVIEW ON FORM FACTORS
        IN THE CHARGED K SECTION OF THE DATA CARD LISTINGS ABOVE

XIA    XIA = F-/F+ (DETERMINED FROM SPECTRA AND KMU3/KE3)   --------------
XIA   SOME OF THE OLDER EXPERIMENTS HAVE EVALUATED XI ASSUMING THAT IT IS
XIA     INDEPENDENT OF THE MOMENTUM TRANSFER (T), I.E., THEY SET L+=L-=0.
XIA     OTHERS HAVE ASSUMED A VALUE FOR L+ AND USED L-=0. ONLY RECENTLY
XIA     BOTH L+,L- AND XI(0) (OR THREE RELATED PARAMETERS) HAVE BEEN INCLU-
XIA     DED IN THE FITS. SEE CHIEN 70, DALLY 72, ALBROW 72.
XIA L  389  (+1.1)     (0.9)     (1.3)  ADAIR      64 HBC     KMU3/KE3           8/67
XIA L       (+0.66)    (0.9)     (1.3)  LUERS      64 HBC     KMU3/KE3           8/67
XIA L 1371  (+1.2)     (0.8)            CARPENTER 66 OSPK     MU,PI SPECTRA      8/67
XIA K        (0.2)     (0.8)     (1.2)  KULYUKINA 68 CC       MU,PI SPECTRA      2/71
XIA    770   +0.3      +0.4             BUDAGOV    68 HLBC    KM3/KE3,LM+=.023 11/68
XIA E 1309  (-0.22)    (0.30)           EVANS      69 HLBC    KM3/KE3,LM+=.02  10/69
XIA   3140   -3.9       0.4             BASILE     70 OSPK    DAL.PLT.LM+=.02  10/70
XIA   3548   -0.50      0.5             BASILE     70 OSPK    KM3/KE3,LM+=.02  10/70
XIA C  16K  (-0.68)    (0.12)     (0.20)CHIEN      70 ASPK    DAL.PLT.LM+=.08   2/71
XIA  A9086   -1.5       0.7             ALBROW     72 ASPK    DAL.PLT.LM+=.085  8/72*
XIA  C 16K    0.50      0.61            DALLY      72 ASPK    DAL.PLT.LM+=.11   1/73*
XIA  E1309   -0.08      0.25            EVANS      73 HLBC    KM3/KE3,LM+=.02   1/73*
XIA L   LM+ AND LM- ASSUMED TO BE ZERO.
XIA K   LM+ AND LM- NOT GIVEN.
XIA C   CHIEN 70 VALUE AT L-=0 . L- AND XI(0) ARE HIGHLY CORRELATED.             2/71
XIA  C  DALLY 72 IS A REANALYSIS OF CHIEN 70, LAMBDA=-0.37+-0.15                 1/73*
XIA  A  ALBROW 72 GETS LM-=0.030+-0.060, LAMBDA=0.15+0.17-0.11                   1/73*
XIA  E  EVANS 73 REPLACES EVANS 69.  LM-=0                                       1/73*
XIA          . . . . . . . . . .
XIA AVERAGE MEANINGLESS (SCALE FACTOR = 4.0)

XIB    XIB = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)   -----------
XIB    THE MU POLARIZATION IS A MEASURE OF XI(T). NO ASSUMPTIONS ON L+-
XIB    NECESSARY, T SHOULD BE SPECIFIED.
XIB     FOR RAD. CORR. TO MUON POLARIZATION IN KMU3, SEE GINSBERG 71.            2/72
XIB   2608   -1.2       0.5             AUERBACH   66 OSPK    POLARIZATION       8/67
XIB    638   -1.6       0.5             ABRAMS     68 OSPK    POLARIZATION       5/69
XIB          -1.81      0.50      0.26  LONGO      69 CNTR    POL. T=2.65       11/69
XIB          . . . . . . . . . .
XIB AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

IXI       IMAGINARY PART OF XI  (TEST OF T REVERSAL)  -----------------
IXI          -0.2       0.6             ABRAMS     68 OSPK    MU POLARIZATION  10/69
IXI          -0.02      0.08            LONGO      69 CNTR    POL. T=2.65      11/69
IXI          . . . . . . . . . .
IXI AVG      -0.023     0.079   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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

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
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L+E      LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KO E3 DECAY)    ------
L+E      FOR RAD. CORR. TO THE DALITZ PLOT OF KE3, SEE GINSBERG 67.
L+E    153   +0.07     .06               LUERS     64 HBC     DLTZ PLOT,NO R.C
L+E    577   +0.15     .08               FISHER    65 OSPK    DLTZ PLT,NO R.C.  8/67
L+E    762   -0.01     .02               FIRESTONE 67 HBC     DLTZ PLT,NO R.C.  8/67
L+E    531   +0.01     .015              KADYK     67 HBC     E,PI SPEC,NO R.C  8/67
L+E    240   +0.08     .10        .08    LOWYS     67 FBC     PI SPEC, RAD COR  8/67
L+E   1000    0.02    0.013              ARONSON   68 OSPK    PI SPECTRUM       5/69
L+E   4800   +0.023   0.012              BASILE    68 OSPK    DLTZ PLT,NO R.C.  3/68
L+E    42K    0.023   0.005              BISI      71 ASPK    DLTZ PLT,R.C.    12/71
L+E    16K    0.05    0.01               CHIEN     71 ASPK    DLTZ PLT,NO R.C.  6/71
L+E   1910    0.022   0.014              NEUHOFER  72 ASPK    PI SPEC, RAD COR  1/73*
L+E         . . . . . . . . .
L+E AVG       0.0249  0.0049  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                              (SEE IDEOGRAM BELOW )
```
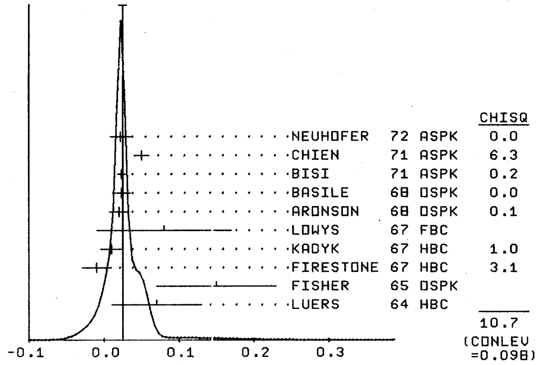

WEIGHTED AVERAGE = 0.0249 ± 0.0049
ERROR SCALED BY 1.3



LAMBDA+ FOR KE3 DECAY OF KOL

```
L+M     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KMU3 DECAY)
L+M      FOR RAD. CORR. TO DALITZ PLOT OF KMU3  SEE GINSBERG 70
L+M C  16K   (0.07)   (0.02)            CHIEN     70 ASPK    XIA=-.68+.12-.20  3/71
L+M  A9086    0.085    0.015            ALBROW    72 ASPK    XIA=-1.5+-0.7     8/72*
L+M  C 16K    0.11     0.04             DALLY     72 ASPK    XIA=.50+-.61      1/73*
L+M C   CHIEN 70 VALUE AND ERROR HAVE BEEN CHANGED FROM 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     SEE ALSO THE CORRESPONDING ENTRIES AND FOOTNOTES IN SEC. XIA ABOVE.     1/73*
L+M         . . . . . . . . .
L+M AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                   13  CP VIOLATION PARAMETERS IN KOL DECAYS

        RELATED TEXT SECTION IV F.3 AND MINI-REVIEW BELOW

-------------------13 CHARGE ASYMMETRY IN TAU DECAYS---------------------
TEXT SECTION IV F.3 B

     SEE SCRIBANO 70 FOR DEFINITION (HIS SIGMA+-). A=1 FOR MAX ASYMMETRY
     (M)**2 = 1+ SIG+- (2/SQRT(3) *((T+)-(T-))/ TMAX)  AS SCRIBANO 70

A      DECAY ASYMMETRY PARAMETER FOR PI+ PI- PIO   (UNITS 10**-2)
A       .3M     0.2       0.95             BLANPIED  68 CNTR                     . 4/70
A        3M     0.27      0.2              SCRIBANO  70 CNTR                     .12/70
A      4400     0.000     0.050            SMITH     70 OSPK                     .10/70
A           . . . . . . . . . .
A     AVG       0.016     0.063   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                                  (SEE IDEOGRAM BELOW )
```
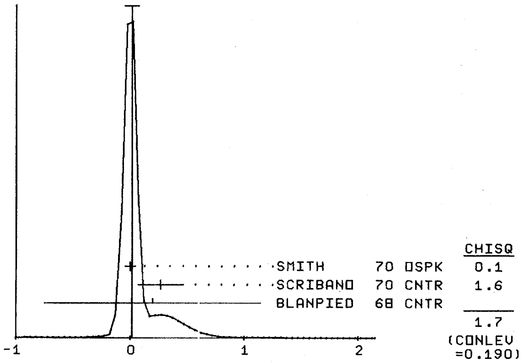

WEIGHTED AVERAGE = 0.016 ± 0.063
ERROR SCALED BY 1.3



DECAY ASYMMETRY FOR KOL INTO PI+ PI- PIO

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--------------------13  CHARGE ASYMMETRY IN LEPTONIC DECAYS (PERCENT)------
TEXT SECTION IV F.3 C

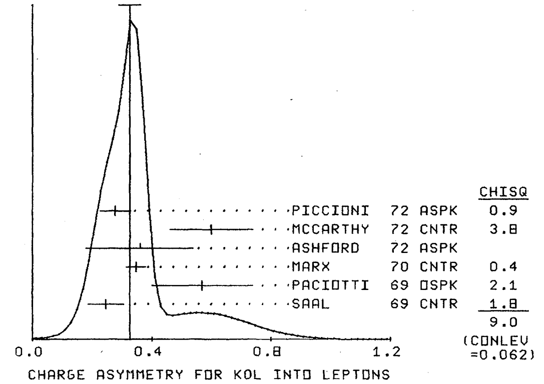
        SUCH ASYMMETRY VIOLATES CP . IT IS RELATED TO REAL(EPSILON).

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     4.1M   0.60     0.14           MCCARTHY  72 CNTR                      1/73*
A1     7.7M   0.278    0.051          PICCIONI  72 ASPK                      1/73*
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       0.334    0.085   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)

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     18M   (0.266)  (0.034)         WEBB      72 ASPK    PRELIMINARY      11/72*
A2  B SAAL 69 IS A REANALYSIS OF BENNETT 67
A2           . . . . . . . . .
A2  AVG       0.323    0.042   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)

AL      KOL INTO ((L+)-(L-))/((L+)+(L-))  (COMBINED A1 AND A2) (PERCENT)
AL B   10M    0.246    0.059          SAAL      69 CNTR                      2/71
AL D    1M    0.57     0.17           PACIOTTI  69 OSPK                      1/73*
AL     10M    0.346    0.033          MARX      70 CNTR                      2/71
AL    600K    0.36     0.18           ASHFORD   72 ASPK                      2/72
AL     4.1M   0.60     0.14           MCCARTHY  72 CNTR                      1/73*
AL     7.7M   0.278    0.051          PICCIONI  72 ASPK                      1/73*
AL     18M   (0.266)  (0.034)         WEBB      72 ASPK    PRELIMINARY      11/72*
AL      SEE FOOTNOTES IN SECTIONS A1 AND A2 ABOVE.                           1/73*
AL           . . . . . . . . .
AL  AVG       0.326    0.036   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                       (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.326 ± 0.036
ERROR SCALED BY 1.5



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--------------------13  PARAMETERS FOR KOL INTO 2PI DECAY------------------
TEXT SECTION IV F.3 D

      ETA+- = A(KL TO PI+PI-)/A(KS TO PI+PI-)
      ETA00 = A(KL TO PIOPIO)/A(KS TO PIOPIO)

      THE FITTED VALUES OF ETA+- AND ETA00 GIVEN BELOW ARE DERIVED
      PRIMARILY FROM THE FITTED BRANCHING RATIOS FOR THE TWO PION DECAY
      MODES OF KOL AND KOS.  FOR THE QUANTITIES MEASURED BY INDIVIDUAL
      EXPERIMENTS SEE THE KOL BRANCHING RATIOS R9 AND R20 (ETA+-) AND
      R17 AND R19 (ETA00).  FOR THE READER'S CONVIENENCE WE LIST THE
      DERIVED QUANTITIES ETA+- (CALLED E+- BELOW) AND (ETA00)**2 (CALLED
      EOS BELOW).  HOWEVER, THE FIT FOR ETA+- AND ETA00 USES ONLY THOSE
      VALUES BELOW WHICH ARE INDEPENDENT OF BRANCHING RATIO MEASUREMENTS--
      ETA00 OF CHOLLET 70 AND WOLFF 71, AND (ETA00/ETA+-) OF BANNER1 72
      AND HOLDER 72.

EOS     (ETA00)**2 = (A(KL TO 2PIO)/A(KS TO 2PIO))**2  (UNITS 10**-6)   ---
EOS       0    -2.       7.0          BARTLETT  68 OSPK                     10/69
EOS      57     4.9      1.2          BANNER    69 OSPK                      2/72
EOS     133    14.1      3.4          CENCE     69 OSPK                     10/69
EOS F   180   (13.)     (4.)          GAILLARD  69 OSPK                     10/69
EOS      29     4.08     0.9          BARMIN    70 HLBC                     12/70
EOS      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  F 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  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 CALCULTIONS 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 2PIO EVENTS AS GAILLARD 69
EOS          . . . . . . . . .
EOS AVG       5.13     0.90    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
EOS FIT       4.35     0.40   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  1/73*
                       (SEE IDEOGRAM BELOW )

E+-    ETA+-  = A(KL TO PI+PI-)/A(KS TO PI+PI-) UNITS 10**-3  -------------
E+-     45   (1.94)                   CHRISTENS 64 OSPK                     10/69
E+-     54   (2.02)                   GALBRAITH 65 OSPK                     10/69
E+-          (1.86)                   BASILE    66 OSPK                     10/69
E+-          (1.935)                  BOTT-BODE 66 OSPK                     10/69
E+-    525    1.91      .06           FITCH     67 OSPK                     10/69
E+-          . . . . . . . . .
E+- FIT       1.980    0.036  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  1/73*
```
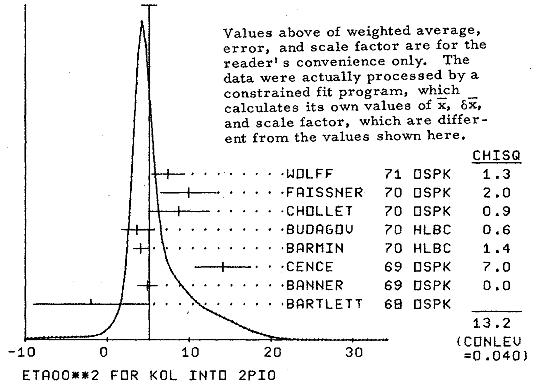

WEIGHTED AVERAGE = 5.13 ± 0.90
ERROR SCALED BY 1.5



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.

```
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           . . . . . . . . .
ER   AVG       1.013    0.046   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
ER   FIT       1.054    0.046  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  1/73*
```

Note on $K_L^0 \to 2\pi$ and K_S Regeneration

Some experiments obtain ϕ_{+-} (the phase of η_{+-}) using K_S, $K_L \to \pi^+\pi^-$ interference behind a regenerator. In these interference experiments the measured quantity is the difference of ϕ_{+-} and the regeneration phase ϕ_R, as shown in the expression below. After the regenerator, the intensity of the $\pi^+\pi^-$ decays in the forward direction is

$$I(t,p) = S(p)\,[\,|R(p)|^2\, e^{-\Gamma_S t} + |\eta_{+-}|^2\, e^{-\Gamma_L t} + 2|R(p)|\,|\eta_{+-}| \times e^{-(\Gamma_S+\Gamma_L)t/2} \cos(\Delta m t + \phi_R(p) - \phi_{+-})], \qquad (1)$$

where:

t is the decay time in the K^0 rest frame,

$\Delta m = m_L - m_S$, and $m_L, \Gamma_L, m_S, \Gamma_S$ are the masses and decay rates of the long- and short-lived K^0,

$\eta_{+-} = |\eta_{+-}|\, e^{i\phi_{+-}}$ is the ratio of decay amplitudes $A(K_L \to \pi^+\pi^-)/A(K_S \to \pi^+\pi^-)$,

$S(p)$ is propotional to the K_L momentum spectrum, and

$R(p) = |R(p)|\, e^{i\phi_R(p)}$ is the transmission-regenerated K_S amplitude (relative to the K_L):

$$R(p) = \pi N \Lambda i\, \frac{[f_0(p) - \bar{f}_0(p)]}{p} \left\{ \frac{1 - e^{-\frac{1}{2}\Gamma_S \ell(p)[1-2i\Delta m/\Gamma_S]}}{\frac{1}{2}\Gamma_S[1-2i\,\Delta m/\Gamma_S]} \right\}, \qquad (2)$$

where

$\ell(p)$ is the thickness of regenerator measured in units of the mean decay length of K_S,
N is the number of nuclei per cubic centimeter,
Λ is the K_S mean decay length, and
$f_0(p), \bar{f}_0(p)$ are the forward scattering amplitude of K^0 and $\bar{K}^0$.

From (1) above it is clear that the value of ϕ_{+-} is correlated with the value of Δm and ϕ_R. Usually Δm is a parameter of the fit and ϕ_R is determined by some other means (optical model calculations, time dependence of the charge asymmetry in K_{e3} decay, etc.).

We list ϕ_{+-} and give in comment cards both the value of ϕ_R used by the authors and the Δm dependence of ϕ_{+-}.

```
F+-     PHASE OF ETA +-          (DEGREES)   -----------------------------
F+-      DM IS (KOL-KOS MASS DIFFERENCE / HBAR) IN UNITS OF 10**10 SEC-1     2/71
F+-           SEE SECTION D OF KOL LISTINGS FOR LATEST VALUE
F+-      WE HAVE ADDED THE MASS DEPENDENCE AND PROPAGATED THE ERROR IN DM    2/71
F+-      USING DM=0.5398+-0.0033 FOR BENNETT 69, BOHM 69, FAISSNER 69,       2/71
F+-      JENSEN 70, AND BALATS 71. THE APRIL 1972 DM(0.5402+-0.0035) WOULD   3/72
F+-      NOT MAKE A SIGNIFICANT CHANGE IN THE PHASE.                         3/72
F+-           45.0     50.0              FITCH     65 OSPK    BE REGEN      11/67
F+-           30.0     45.0              FIRESTONE 66 HBC                   11/67
F+-           70.0     21.0              BOTT-BODE 67 OSPK    C REGEN       11/67
F+-           25.0     35.0              MISCHKE   67 OSPK    CU REGEN       7/68
F+- N        (51.0)   (11.0)             BENNETT2  68 CNTR    CU REG. USES   8/68
F+-  C        34.5     10.0              BENNETT   69 CNTR    CU REGEN       2/71
F+-  B        47.6     12.1              BOHM      69 OSPK    VACUUM REGEN   2/71
F+-  F        46.2      7.4              FAISSNER  69 ASPK    CU REGEN       2/71
F+-  J        43.4      4.4              JENSEN    70 ASPK    VACUUM REGEN   2/71
F+-  D        38.0     12.0              BALATS    71 OSPK    CU REGEN       9/71
F+-  P        36.2      6.1              CARNEGIE  72 ASPK                   1/73*
F+-         . . . . . . . . .
F+- AVG       41.8      2.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
                    COMMENTS
F+-  N  BENNETT 69 IS A REEVALUATION OF BENNETT2 68.                        11/69
F+-  C  BENNET 69 USES MEASUREMENT OF (F+-)-(PHIF) OF ALFF-STEI 66           2/71
F+-  C  BENNETT 69 F+-= 34.9+-10.0, NOT INCLUDING ERROR IN DM                2/71
F+-  C  DM DEPENDENCE OF BENNETT 69 IS 69*(DM-0.545) DEG. FR=-49.9+-5.4DEG.  2/71
F+-  B  BOHM 69 F+-=41+-12, NOT INCLUDING ERROR IN DM.                       2/71
F+-  B  DM DEPENDENCE OF BOHM 69 IS 479*(DM-0.526) 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, NOT INCLUDING ERROR IN DM.                2/71
F+-  F  DM DEPENDENCE OF FAISSNER 69 IS 205*(DM-0.555) DEG. FR=-42.7+-5DEG.  2/71
F+-  J  JENSEN 70 F+-=42.4+-4.0, NOT INCLUDING ERROR IN DM.                  2/71
F+-  J  DM DEPENDENCE OF JENSEN 70 IS 576*(DM-0.538) DEG.                    2/71
F+-  D  BALATS 71 F+-=39+-12, NOT INCLUDING ERROR IN DM. FR=-43+-4 DEG.      9/71
F+-  D  DM DEPENDENCE OF BALATS 71 IS 198*(DM-.544) DEG.                     9/71
F+-  P  CARNEGIE 72 INSENSITIVE TO DM. FR=-56.2+-5.2 DEG..                   1/73*

FOO     PHASE OF ETA 00    (DEGREES)    ------------------------------
FOO    FIRST QUADRANT PREFERRED          GOBBI     69 OSPK                  11/69
FOO  C          51.      30.             CHOLLET   70 OSPK    CU REG.,4 GAMMAS 10/70
FOO  W  56    38.0     25.0              WOLFF     71 OSPK    CU REG.,4GAMMAS  12/71
FOO         . . . . . . . . .
FOO AVG       43.3     19.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
FOO  C  CHOLLET 70 USES REGENERATOR PHASE FR=-46.5+-4.4 DEG.                 1/73*
FOO  W  WOLFF 71   USES REGENERATOR PHASE FR=-48.2+-3.5 DEG.                 1/73*
```

Superweak Model Predictions

for $\phi_{\eta_{+-}}$ and $\phi_{\eta_{00}}$

The superweak model of Wolfenstein, Phys. Letters 13, 562 (1964) predicts that

$$\phi_{+-} = \phi_{00} = \tan^{-1}\left(\frac{2\Delta m\,\tau_S}{\hbar}\right)$$

and

$$\mathrm{Re}\,\epsilon = |\eta_{+-}|\left[1 + \left(\frac{2\Delta m\,\tau_S}{\hbar}\right)^2\right]^{-1/2}$$

The K_L^0-K_S^0 mass difference, the K_S lifetime, and $|\eta_{+-}|$ given in the Stable Particle Table result in the predictions that

$$\phi_{+-} = \phi_{00} = (43.63 \pm 0.32)°$$

and

$$\mathrm{Re}\,\epsilon = (1.433 \pm 0.027) \times 10^{-3}.$$

These can be compared with the experimental values

$$\phi_{+-} = (41.8 \pm 2.8)°$$

$$\phi_{00} = (43 \pm 19)°$$

$$\mathrm{Re}\,\epsilon = (1.62 \pm 0.20) \times 10^{-3}$$

where ϵ has been computed from δ, the charge asymmetry parameter for leptonic K_L^0 decays, and (Re x, Im x), the $\Delta S = -\Delta Q$ amplitude, using Eq. (34) of the text.

As noted in the mini-review preceding the K_S^0 mean life, the measured values of Δm and ϕ_{+-} used above have not been adjusted for our new value of τ_S. Had we used the adjusted value for Δm, the predictions would be

$$\phi_{+-} = \phi_{00} = (43.95 \pm .32)^0$$

and

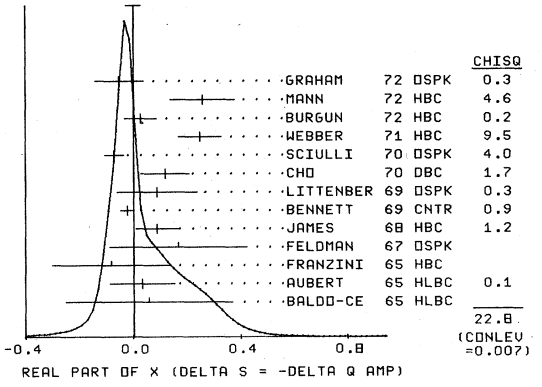
$$\mathrm{Re}\,\epsilon = (1.426 \pm 0.027) \times 10^{-3}.$$

The measured value of ϕ_{+-} would be adjusted to

$$\phi_{+-} \simeq (45.2 \pm 2.8)^0.$$

```
              13  X = (DS=-DQ AMPLITUDE)/(DS=+DQ AMPLITUDE)

      RELATED TEXT SECTION IV F.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    1079    -0.069     0.036           SCIULLI    70 OSPK    PI-P             11/70
REX     252     0.25       .07       .09  WEBBER     71 HBC     K-P TO KBAR N    10/69
REX     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 G    SECOND GRAHAM 72 VALUE IS FIRST GRAHAM 72 VALUE COMBINED WITH            2/72
REX G    MANTSCH 72.                                                              2/72
REX   B  BENNETT 69 IS A REANALYSIS OF BENNETT1 68
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.
REX         . . . . . . . . . .
REX AVG        0.003     0.027    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
                         (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.003 ± 0.027
ERROR SCALED BY 1.6



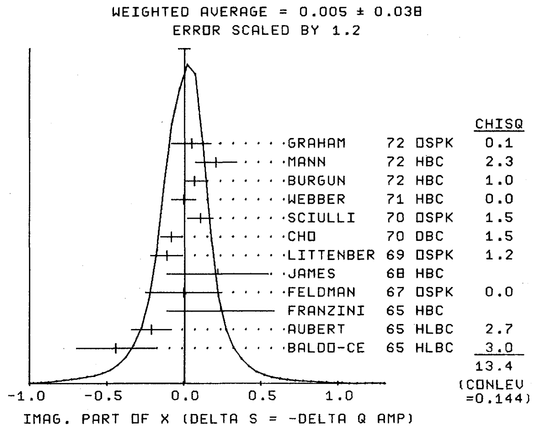
Stable Particles

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   1079     0.108    0.092    0.074 SCIULLI   70 OSPK    PI-P             11/70
IMX    252     0.0       .08           WEBBER    71 HBC     K-P TO KBAR N    10/69
IMX    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 G    SECOND GRAHAM 72 VALUE IS FIRST GRAHAM 72 VALUE COMBINED WITH        2/72
IMX G    MANTSCH 72.                                                          2/72
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.
IMX          . . . . . . . . .
IMX AVG        0.005    0.038   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                                (SEE IDEOGRAM BELOW )
```



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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)

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 28         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)

SCIULLI  70 PRL 25 1214          +GALLIVAN,BINNIE,GOMEZ,MALLARY,PECK+  (CIT)
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)
CARNEGIE 71 PR D4 1              +CESTER,FITCH,STROVINK,SULAK         (PRIN)
CHAN     71 LBL-350  THESIS      J.HIONG-SING CHAN                     (LBL)
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

K_L^0, η

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CHIEN     71 PL 35B 261          +COX,ETTLINGER,RESVANIS+     (JHU,SLAC,UCLA)
    ALSO 72 DALLY

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)
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)
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)
BURGUN    72 NP B50 194          +LESQUOY,MULLER,PAULI,+     (SACL+CERN+OSLO)
    ALSO 71 LNC 2 1169           BURGUN,LESQUOY,MULLER +     (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
    ALSO 71 CHIEN
GRAHAM    72 NC 9A 166           +ABASHIAN,JONES,MANTSCH,ORR+       (ILL+NEAS)
HOLDER    72 PL 40B 141          +RADERMACHER,STAUDE+        (AACH+CERN+TORI)
JAMES     72 NP B49 1            +MONTANET,PAUL,SAETRE+      (CERN+SACL+OSLO)
    ALSO 71 PL 35B 265           JAMES,MONTANET,PAUL,PAULI+ (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)
MCCARTHY 72 PL 42B 291           +BREWER,BUDNITZ,ENTIS,GRAVEN,MILLER+  (LBL)
    ALSO 71 THESIS LBL - 550  R.L.MCCARTHY                            (LBL)
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)
VOSBURGH 72 PR D6 1834           +DEVLIN,ESTERLING,GOZ,BRYMAN +  (RUTG,MASA)
    ALSO 71 PRL 26 866           VOSBURGH,DEVLIN,ESTERLING,GOZ + (RUTG,MASA)
WEBB      72 THESIS              ROBERT CARROLL WEBB             (PRINCETON)

CARITHER 73 BAPS 18 26           CARITHERS,MODIS,NYGREN,PUN+ (COLU+CERN+NYU)
EVANS     73 PR D7 36            +MUIR,PEACH,BUDAGOV+       (EDINBURGH+CERN)
    ALSO 69 PRL 23 427           EVANS,GOLDEN,MUIR,PEACH+   (EDINBURGH+CERN)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

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)
GINSBERG 70 PR D1 229            E S GINSBERG                      (IIT HAIFA)
HEUSSE    70 LNC  3 449          +AUBERT,PASCAUD,VIALLE                 (ORSAY)
GINSBERG 71 PR D4 2893           E S GINSBERG                             (MIT)

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$\boxed{\eta}$

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                 14   ETA (549,JPG=0-+) I=0

      FOR C. BALTAY'S REVIEW OF THE ETA MESON, SEE PROC. UNIV. OF PENN.
      CONF. ON MESON SPECTROSCOPY (W.A.BENJAMIN, N.Y., 1968)

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                 14   ETA MASS (MEV)

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)
                         (SEE IDEOGRAM BELOW )

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                 14   ETA WIDTH (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
    ALSO SEE ETA DECAY RATES (BELOW).

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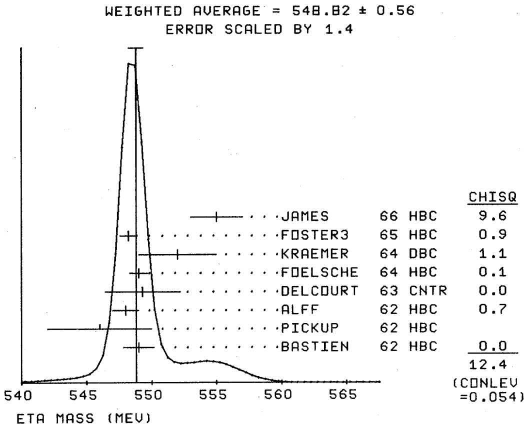

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                 14   ETA PARTIAL DECAY MODES

                                                        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

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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 1 .3800+-.0098
 P 2   -.2763  .3000+-.0107
 P 3   -.3387     -.2116  .2390+-.0055
 P 4   -.3091     -.1946      .8630  .0497+-.0013
 P 7   -.4203     -.5972     -.0815     -.0725  .0313+-.0111
------ --------- --------- --------- --------- --------- --------- --------

                 14   ETA DECAY RATES

W1      ETA INTO 2GAMMA (UNITS KEV)                        (G1)
W1           (0.93)   (0.2)          BEMPORAD   67 CNTR    PRIMAKOFF EFFECT 11/67
```

The above value for $\Gamma_{\gamma\gamma}$ assumes that $\Gamma_{\gamma\gamma}/\Gamma_{\text{total}} = 31.4\%$. However, the results of that experiment may be stated more generally than is given in the paper, as

$$\Gamma_{\gamma\gamma} \times \frac{\Gamma_{\gamma\gamma}}{\Gamma_{\text{total}}} = 0.380 \pm 0.083\ \text{keV}$$

(private communication from C. Bemporad). Thus our new value of

$$\Gamma_{\gamma\gamma}/\Gamma_{\text{total}} = 38.0 \pm 1.0\,\%$$

would give

$$\Gamma_{\gamma\gamma} = 1.00 \pm 0.22\ \text{keV}$$

and

$$\Gamma_{\text{total}} = 2.63 \pm 0.58\ \text{keV}.$$

See G. Benfatto, "Coherent Nuclear Photoproduction of the η-meson," Nuovo Cimento 69A, 109 (1970) for a critique of this technique.

```
                    14  ETA BRANCHING RATIOS

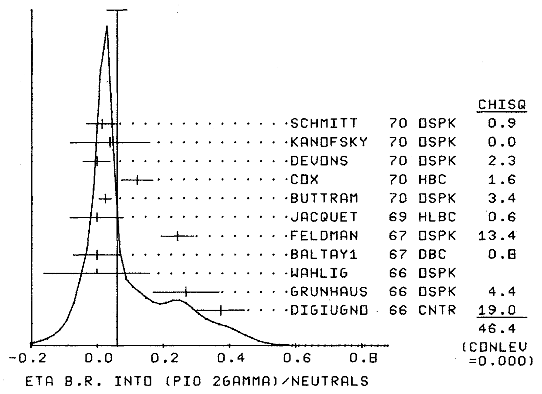
R1      ETA INTO NEUTRALS/CHARGED                          (P1+P2+P7)/(P3+P4)
R1  N   10   (2.5)    (1.0)         PICKUP    62 HBC
R1  N   53   (3.20)   (1.26)        BASTIEN   62 HBC
R1  N        (2.7)    (0.8)         SHAFER    62 HBC
R1             2.6      .9          BUSCHBECK 63 HBC                         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  FIT        2.463    0.080 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R2      ETA INTO 2GAMMA/CHARGED                            (P1)/(P3+P4)
R2             0.99     0.48        CRAWFORD  63 HBC
R2          . . . . . . . . .
R2  FIT        1.316    0.053 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
```

Note on $\eta \rightarrow \pi^0 \gamma\gamma$

The discrepancies between various measurements of branching ratios involving $\eta \rightarrow \pi^0\gamma\gamma$ 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.

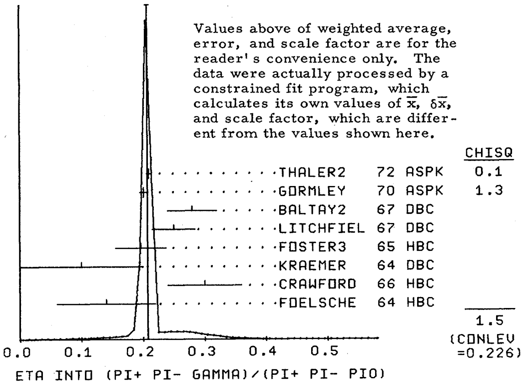
WEIGHTED AVERAGE = 0.061 ± 0.031
ERROR SCALED BY 2.3



```
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  FIT        0.044    0.016  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    0.003       THALER2   72 ASPK                        1/73*
R4          . . . . . . . . .
R4  AVG        0.2080   0.0032  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R4  FIT        0.2080   0.0027 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
                        (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.2080 ± 0.0032
ERROR SCALED BY 1.2

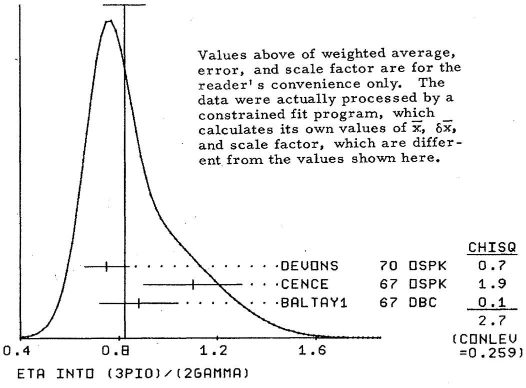


Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\overline{x}$, $\delta\overline{x}$, and scale factor, which are different from the values shown here.

```
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  FIT        1.342    0.055  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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  FIT        0.790    0.039  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                        (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.824 ± 0.085
ERROR SCALED BY 1.2



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.

```
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  FIT        1.590    0.064  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
```

Data Card Listings

For notation, see key at front of Listings.

```
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 B   ERROR INCREASED FROM PUBLISHED VALUE 0.5 BY BLOODWORTH, PRIV. COMM.  1/73*
R8          . . . . . . . . . .
R8  AVG      3.28     0.31    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  FIT      2.976    0.097  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R9      ETA INTO (E+E-PIO)/(PI+PI-PIO) (UNITS 10**-2)        (P5)/(P3)
R9           1.1   OR LESS           PRICE      65 HBC
R9      0    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

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         . . . . . . . . . .
R12 AVG      0.535    0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R12 FIT      0.534    0.013  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R13     ETA INTO 3PIO/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         . . . . . . . . . .
R13 AVG      0.397    0.025   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R13 FIT      0.422    0.015  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R14     ETA INTO PIO (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      0.082    0.030  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R15     ETA INTO (E+E-PIO)/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

R16     ETA INTO 2GAMMA/(3PIO + PIO 2GAMMA)                  (P1)/(P2+P7)
R16          0.80      .25           BACCI      63 CNTR                  7/66
R16         . . . . . . . . . .
R16 FIT      1.147    0.060  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R17     ETA INTO (PI+PI-PIO GAMMA)/(PI+PI-PIO)               (P10)/(P3)
R17          (.07) OR LESS           FLATTE     67 HBC                   8/67
R17          (.009)OR LESS           PRICE      67 HBC                   8/67
R17          (.016)OR LESS  CL=.95   BALTAY2    67 DBC                  11/67
R17         (0.017)OR LESS  CL=.90   ARNOLD     68 HLBC                  9/68
R17          0.035 OR LESS  CL=.90   THALER2    72 ASPK                  1/73*

R18     ETA INTO (PI+PI- 2GAMMA)/(PI+PI-PIO)                 (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 3PIO/(PI+ PI- PIO)                          (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 FIT      1.255    0.058  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R20     ETA INTO 2GAMMA/((3PIO)+2/3(PIO 2GAMMA))             (P1)/(P2+2/3P7)
R20          1.10     0.5            MULLER     63 DBC                   7/66
R20         . . . . . . . . . .
R20 FIT      1.184    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 FIT      0.7113   0.0067 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R22     ETA INTO (PIO 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-PIO/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 (PIO 2GAMMA)/(3PIO + PIO 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      0.094    0.032  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

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                 14  ETA C-NONCONSERVING DECAY PARAMETER

        RELATED TEXT SECTION IV G AND MINI-REVIEW BELOW

A    DECAY ASYMMETRY PARAMETER FOR PI+ PI- PIO   (UNITS 10**-2)
A      1351    7.2      2.8            BALTAY    66 DBC                   8/66
A      1300    5.8      3.4            CLPWY     66 HBC                   8/66
A     10665   (0.3)    (1.0)           CNOPS     66 OSPK REPL BY MULLER 69 8/67
A       705   -6.1      4.0            LARRIBE   66 HBC                   8/67
A     36800    1.5       .5            GORMLEY3  68 ASPK                  6/68
A     10709     .3      1.1            MULLER    69 OSPK                  9/69
A      1138   -1.4      3.             CARPENTR  70 HBC                   6/70
A       349    3.2      5.4            DANBURG   70 DBC                   2/71
A  L   220K   -0.05     0.22           LAYTER    72 ASPK                  8/72*
A  L     ALSO REPORTS SEXTANT AND QUADRANT ASYMMETRIES.                   8/72*
A             . . . . . . . . .
A    AVG       0.24     0.40    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
                       (SEE IDEOGRAM BELOW )
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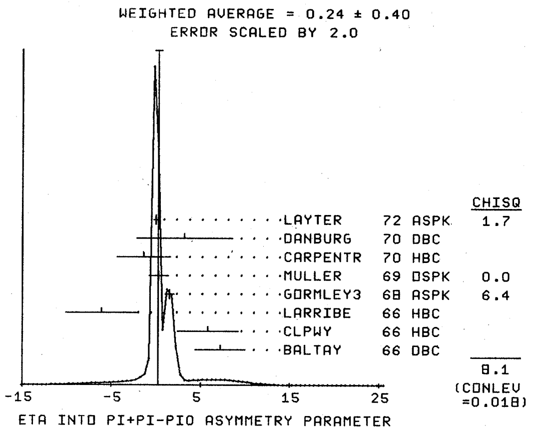

H. Yuta and S. Okubo [Phys. Rev. Letters 21, 781 (1968)] have pointed out that an asymmetry in the decay $\eta \rightarrow \pi^+\pi^-\pi^0$ of about 2% need not imply a breakdown of C invariance, since an asymmetry of this amount could be caused by an interference between the η and the 3π background. Gormley et al. [Phys. Rev. Letters 22, 198 (1969)], however, believe that this effect can account for only $\leqslant 0.23\%$ in their experiment (above). Also see: A. Frenkel and G. Vesztergombi, "C-Violation in η-Decay," Nucl. Phys. B15, 429 (1970) and K. Taggart, "Asymmetry and Background in $\eta \rightarrow 3\pi$," Phys. Rev. D 2, 1960 (1970).

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B    DECAY ASYMMETRY PARAMETER FOR PI+ PI- GAMMA (UNITS 10**-2)
B        33   -2.       17.            CRAWFORD  66 HBC                  11/66
B             -4.        8.            LITCHFIEL 67 DBC                   8/67
B  N   1620    1.5       2.5           MULLER    69 OSPK                  9/69
B  N   ABOVE EXPERIMENT IS SENSITIVE ONLY TO UPPER .4 OF GAMMA-RAY SPECTRUM
B      7257    1.22      1.56          GORMLEY   70 ASPK                  6/70
B       36K    0.5       0.6           THALER1   72 ASPK                  8/72*
B              . . . . . . . . .
B    AVG       0.61      0.54    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                              REFERENCES FOR ETA

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+ROMA)

FOELSCHE 64 PR 134 B 1138      H W FOELSCHE,H L KRAYBILL              (YALE)
KRAEMER  64 PR 136 B 496       KRAEMER,MADANSKY,FIELDS +   (JHU+NWES+WOOD)
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)
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Stable Particles

η, p, n

Data Card Listings

For notation, see key at front of Listings.

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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)
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,(LOIC,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,BONN)
    ALSO    PRIVATE COMMUNICATION
BILLING  67 PL 25B 435          BILLING,BULLOCK,ESTEN,GOVAN,+     (LOUC,OXF)
BONAMY   67 HEIDELBERG CONF.    BONAMY,SONDEREGGER                 (SACLAY)
BUNIATOV 67 PL 25B 560          BUNIATOV,ZAVATTINI,DEINET,+      (CERN+KARL)
CENCE    67 PRL 19 1393         CENCE,PETERSON,STENGER,CHIU+    (HAWAII+LRL)
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)
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)

BUTTRAM  70 PRL 25 1358         +KREISLER,MISCHKE                    (PRIN)
COX      70 PRL 24 534          COX,FORTNEY,GOLSON                   (DUKE)
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)

        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)

           REFERENCES ON ETA ASYMMETRY PARAMETERS

BALTAY   66 PRL  16  1224       BALTAY,FRANZINI,KIM,KIRSCH+      (COLU+STON)
CNOPS    66 PL 22 546           CNOPS,FINOCCHIARS,LASSALLE,(CERN,ETHZ,SACL)
CRAWFORD 66 PRL  16  333        F.S.CRAWFORD,L.R.PRICE                (LRL)
CLPWY    66 PR 149  1044        COLUMBIA,LRL,PURDUE,WISCONSIN,YALE
LARRIBE  66 PL 23 600           LARRIBE,LEVEQUE,MULLER,PAULI,+  (SACL+RHEL)

BOWEN    67 PL 24B 206          BOWEN,CNOPS ,FINOCCHIARO,+ (CERN+ETHZ+SACL)
LITCHFIE 67 PL 24B 486          LITCHFIELD,RANGAN,SEGAR,SMITH+(RHEL+SACLAY)
GORMLEY3 68 PRL 21 402          GORMLEY,HYMAN,LEE,NASH,PEOPLES+  (COLU+BNL)
MULLER   69 THESIS              ARMAND MULLER                        (STRB)
CARPENTR 70 PR D1 1303          CARPENTER,BINKLEY,CHAPMAN,COX,DAGAN+ (DUKE)
DANBURG  70 PR D2 2564          +ABOLINS,DAHL,DAVIES,HOCH,KIRZ,+      (LRL)
LAYTER   72 PRL 29 316          +APPEL,KOTLEWSKI,LEE,STEIN,THALER    (COLU)
THALER1  72 PRL 29 313          +APPEL,KOTLEWSKI,LAYTER,LEE,STEIN    (COLU)
THALER2  72 NEVIS 194(THESIS)   JON J THALER                         (COLU)

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 p              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   .0052         TAYLOR    69 RVUE   USING NEW E/H   7/70

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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   B    KROPP AND BACKENSTOSS SENSITIVE TO PARTICULAR DECAY MODES OF PROT

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                16  PROTON MAGNET. MOMENT(E/2MP)

MM         (2.792763(0.000030)       COHEN     65 RVUE
MM          2.792782  .000017        TAYLOR    69 RVUE   USING NEW E/H   7/70

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                16  ANTIPROTON MAGNETIC MOMENT (E/2MP)

MM1          -2.83     0.10          FOX       72                       11/72*

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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

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                         REFERENCES FOR PROTON

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)
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)
FOX      72 PRL 29 193        FOX,BARNES,EISENSTEIN+ (CARN+VPI+WILL+WYOM)

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 n              17  NEUTRON (939,J=1/2) I=1/2
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                17  NEUTRON MASS (MEV)

M T         939.5527    .0052         TAYLOR    69 RVUE    USING NEW E/H     7/70
M T     TAYLOR DETERMINATION 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  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 MAGNETIC MOMENT (MAGNETONS,938.2 MEV)

MM          -1.913148 0.000066        COHEN     56 RVUE                      7/66

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                17  NEUTRON ELECTRIC DIPOLE MOMENT (UNITS 10**-23 E CM)
            TEST OF C VIOLATION IN THE EM INTERACTION

EDM          (5.)   OR LESS           BAIRD     69 MBR                      10/69

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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            (1.012)  (0.021)         SOSNOVSKI 59 PILE     SEE NOTE E       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*
     E  ERROR CHANGED BECAUSE ERROR IN CROSS SECTION FOR NEUTRON ABSORPTION
     E  IN GOLD HAS BEEN REDUCED.

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                17  NEUTRON BETA DECAY COUPLING CONSTANTS

        RELATED TEXT SECTION IV H.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       -1.248    0.010          KROPF     73 RVUE    N DEC.+ FT VALUE  1/73*
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*

F       PHASE ANGLE OF GA RELATIVE TO GV  (DEGREES)
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   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*

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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)

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)
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)
CHRISTEN 70 PR C1 1693        CHRISTENSEN,KROHN,RINGO               (ANL)
EROZOLIM 70 SJNP 11 583       EROZOLIMSKI,BONDARENKO,  +    (KURC MOSCOW)
    ALSO    PL 27B 557        EROZOLIMSKY,BONDARENKO  +  (KURC IN MOSCOW)
EROZOLIM 71 JETPL 13 252      EROZOLIMSKII,BONDARENKO +     (KURC MOSCOW)
CHRISTEN 72 PR D5 1628        CHRISTENSEN,NIELSON,BAHNSEN,BROWN+   (RISO)
KROPF    73 SUBM. TO NP A     A KROPF,H PAUL                       (LINZ)
    ALSO 70 NP A154 160       H PAUL                               (VIEN)

                              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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Data Card Listings

For notation, see key at front of Listings.

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Λ             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.

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 1115.63      0.07            SCHMIDT   65 HBC  SEE NOTE N           6/68
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    1115.558     0.052   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
M   FIT    1115.592     0.046  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)   1/73*
                       (SEE IDEOGRAM BELOW )
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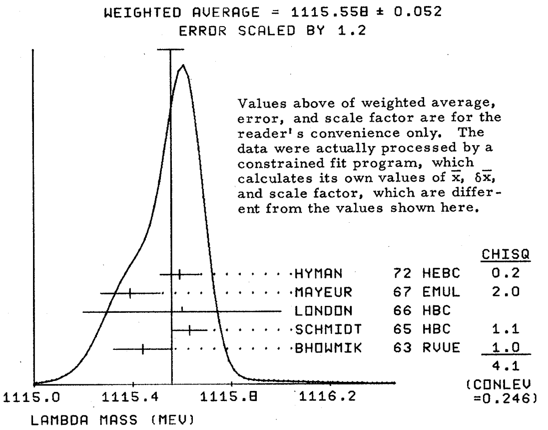

Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\overline{x}$, $\delta\overline{x}$, and scale factor, which are different from the values shown here.

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              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)

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              18  LAMBDA MEAN LIFE (UNITS 10**-10)

T      188     2.63      0.21      0.21  BOLDT      58 CC
T      825     2.72      0.16      0.16  CRAWFORD   59 HBC
T      140     2.72      0.29      0.27  BOWEN      60 CC
T      186     2.60      0.28      0.20  CHANG      62 HBC
T      799     2.69      0.11      0.11  HUMPHREY   62 HBC
T     2239     2.36      0.06      0.06  BLOCK      63 HEBC
T      706     2.76      0.20            CHRETIEN   63 HLBC
T      794     2.59      0.09            HUBBARD    64 HBC
T     2260     2.31      0.10            KREISLER   64 OSPK
T     1378     2.59      0.07            SCHWARTZ   64 HBC
T      635     2.51      0.16            BALTAY     65 HBC                    6/66
T     2534     2.6       0.1             HILL       65 OSPK
T      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     2213     2.452     0.056    0.054  ENGELMANN  66 HBC                    9/66
T      585     2.68      0.13      0.11  AUERBACH   67 OSPK                   8/67
T              2.44      0.15            BADIER     67 HBC    2.4 PBAR P       6/68
T              2.55      0.15            BADIER     67 HBC    2.4 PBAR P,ANTIL 6/68
T     8342     2.535     0.035           GRIMM      68 HBC                    6/68
T     2600     2.47      0.08            HEPP       68 HBC                    8/68
T     1059     2.39      0.10            DEMIDOV    70 HLBC PI-P, 3.86 GEV/C 12/70
T     4572     2.54      0.04            BALTAY     71 HBC     K-P AT REST    6/71
T   S   ERROR PURELY STATISTICAL.
T          . . . . . . . . .
T   AVG        2.521     0.021     0.021  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.2)
                        (SEE IDEOGRAM BELOW )

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              18  ((LAMBDA) - (ANTI-LAMBDA))/AVG., MEAN LIFE DIFFERENCE

DT             0.044     0.085           BADIER     67 HBC     2.4 PBAR P      8/67

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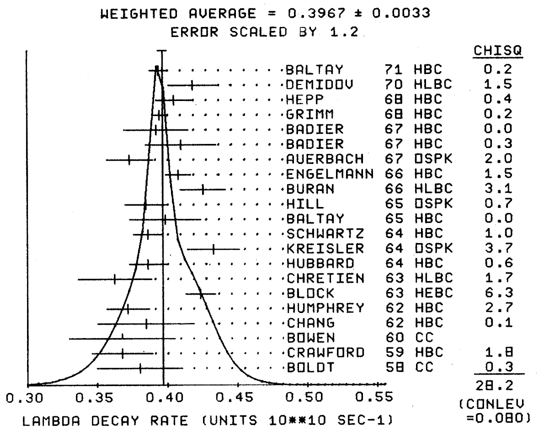

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              18  LAMBDA MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

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        . . . . . . . . .
MM  AVG     -0.672     0.061    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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   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   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)           MALONEY    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)
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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              MALONEY    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   C 218      1.32      0.15              LINDQUIST  71 OSPK     PI-P TO KO LAM     3/72
R5   C  CALCULATED BY US FROM R3 ASSUMING THE AUTHORS USED (P PI-)/TOT=2/3             3/72
R5          . . . . . . . . .
R5  AVG         1.267     0.044    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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 IV H 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-          . . . . . . . . .
A-  AVG         0.647     0.013    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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 O     DONE BY COMPARING 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)

AV       GA/GV FOR LAMBDA BETA DECAY (SEE TEXT SEC. IV H.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          -1.14       0.23       0.33     CONFORTO   65 RVUE                     11/67
AV M   148  -0.72       0.14       0.19     MALONEY    69 HBC                      10/69
AV A  1078  -0.62       0.08       0.09     ALTHOFF2   71 OSPK POLARIZED LAMBDAS    2/72
AV M   141  -0.75       0.15       0.18     CANTER     71 HBC                       4/71
AV  L  173 (-0.32)     (0.13)     (0.17)    LINDQUIST  71 OSPK   UP-DOWN ASYMMETRY  9/71
AV ML  173 (-0.68)     (0.27)     (0.54)    LINDQUIST  71 OSPK   E-NEU CORRELATION  9/71
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  C    EXPERIMENTS INCLUDED IN CONFORTO 65, RVUE                                  6/68
AV M     EXPT MEASURES ONLY THE ABSOLUTE VALUE OF A/V
AV A     USES E AND PROTON UP-DOWN ASYMM AND E-NEU CORRELATIONS                     2/72
AV  L    LINDQUIST 71 GETS THREE VALUES.  WE AVERAGE THE ONE THAT USES             10/71
AV  L    ALL DATA.                                                                 10/71
AV          . . . . . . . . .
AV  AVG        -0.665     0.063    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                          (SEE IDEOGRAM BELOW )
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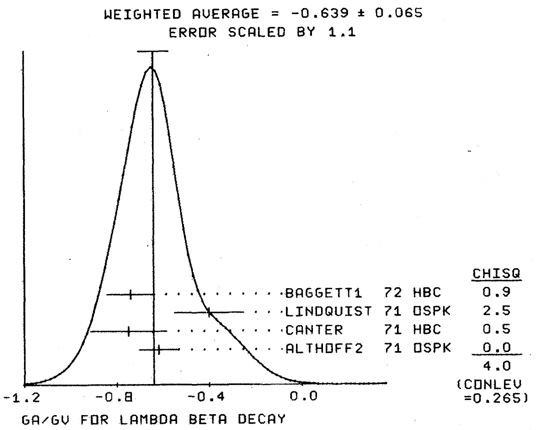

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                        REFERENCES FOR LAMBDA

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           LINDQU+ST,SUMNE-+          (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)
CLELAND  72 NP B40 221           +CONFORTO,EATON,GERBER+    (CERN+GEVA+LUND)
HYMAN    72 PR D5 1063           +BUNNELL,DERRICK,FIELDS,KATZ+    (ANL+CARN)

                                 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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Σ+

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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 1189.68     0.10              SCHMIDT   65 HBC  SEE NOTE N            6/68
M          1189.16     0.12              HYMAN     67 HEBC                       6/68
M      607 1189.39     0.06              BOHM      72 EMUL                       1/73*
M          . . . . . . . . .
M   AVG    1189.418    0.076   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
M   FIT    1189.406    0.068  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)  1/73*
                       (SEE IDEOGRAM BELOW )
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

Σ^+

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           WEIGHTED AVERAGE = 1189.418 ± 0.076
                 ERROR SCALED BY 1.7
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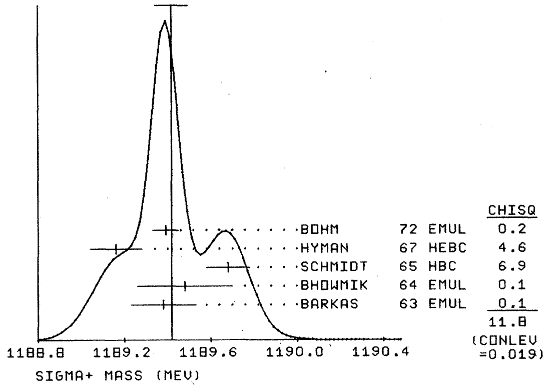

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                  19  SIGMA+ MEAN LIFE (UNITS 10**-10)

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     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   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       0.8004   0.0058   0.0057 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)

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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             . . . . . . . . .
MM   AVG      2.59    0.46    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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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                  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             . . . . . . . . .
R1   AVG      0.4835  0.0073  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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

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)
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R4      SIGMA+ INTO (P GAMMA)/(P PIO) (UNITS 10**-2)      (P5)/(P1)
R4        1   (0.68) 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)
                        (SEE IDEOGRAM BELOW )

             WEIGHTED AVERAGE = 0.240 ± 0.035
                  ERROR SCALED BY 1.4
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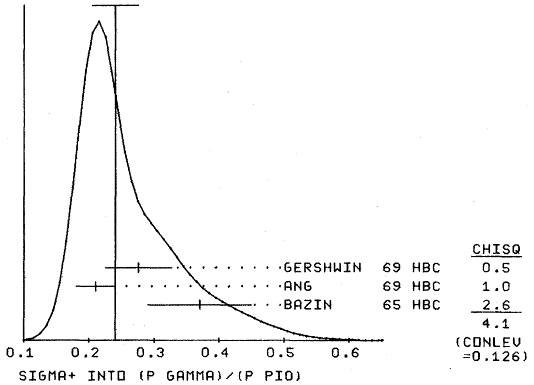

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R5      SIGMA+ INTO (N E+ NEU)/(N PI+) (UNITS 10**-5)     (P7)/(P2)
R5 E      0     16220 EFFECTIVE DENOM.  COURANT   64 HBC     SEE NOTE E      11/67
R5 E      0      2720 EFFECTIVE DENOM.  MURPHY    64 HBC     SEE NOTE E      11/67
R5 E      1      9690 EFFECTIVE DENOM.  NAUENBERG 64 HBC     SEE NOTE E       6/68
R5        0   (32406)EFFECTIVE DENOM.   BIERMAN   68 HBC                      6/68
R5 UA     0   (80400)EFFECTIVE DENOM.   EISELE2   69 HBC  +  STOP K-          6/68
R5 U      1     30000 EFFECTIVE DENOM.  NORTON    69 HBC                     11/69
R5 U      0    110200 EFFECTIVE DENOM.  EBENHOH   70 HBC     STOP K-         12/70
R5 U                  EFFECTIVE DENOM. CALCULATED BY US
R5 E                  EFFECTIVE DENOM.  TAKEN FROM EISELE 67                 11/67
R5  A        EISELE2 69 REPLACED BY EBENHOH 70
R5             . . . . . . . . .
R5       4.0     2.0   OR LESS  CL=.90   OUR AVERAGE USING ALL ABOVE          12/70
R5        NUMBER OF EVENTS INCREASED TO 4.0 FOR 90PC CONFIDENCE LEVEL          2/71

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             . . . . . . . . .
R6       5.3     4.9   OR LESS  CL=.90   OUR AVERAGE USING ALL ABOVE          11/69
R6        NUMBER OF EVENTS INCREASED TO 5.3 FOR 90PC CONFIDENCE LEVEL          2/71
R6                    SEE NOTES ACCOMPANYING R5

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       6.7    0.035 OR LESS  CL=.90   OUR AVERAGE  USING R5 AND R6           2/71
R7        NUMBER OF EVENTS INCREASED TO 6.7 FOR 90PC CONFIDENCE LEVEL          2/71

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       5.3    0.095 OR LESS  CL=.90   OUR AVERAGE  USING R6                  2/71
R9        NUMBER OF EVENTS INCREASED TO 5.3 FOR 90PC CONFIDENCE LEVEL          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       0     0.019 OR LESS  CL=.90   EBENHOH   70 HBC     STOP K-          12/70
R10       0     0.12  OR LESS  CL=.95   COLE      71 HBC     STOP K-          10/71
R10 E        EISELE2 REPLACED BY EBENHOH 70
R10            . . . . . . . . .
R10      4.0    0.016 OR LESS  CL=.90   OUR AVERAGE  USING R5                  2/71
R10       NUMBER OF EVENTS INCREASED TO 4.0 FOR 90PC CONFIDENCE LEVEL          2/71

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                  19  SIGMA+ DECAY PARAMETERS

          RELATED TEXT SECTION IV H 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 0 3500    (-.014)   (0.052)          BANGERTER 66 HBC  +  SIG+ FROM K-P     9/66
A+0 0 2600    (-.047)   (.07)            BERLEY    66 HBC  +  SIG+ FROM K-P     9/66
A+0 0          OLD RESULTS,HAVE BEEN REPLACED . SEE BELOW -

A+        ALPHA 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)
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AO      ALPHA SIGMAO (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 H  DECAY PROTONS SCATTERED OFF CARBON
AO          . . . . . . . . .
AO  AVG       -0.984    0.017   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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)

AG       ALPHA SIGMAG (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 H     DECAY PROTONS SCATTERED OFF CARBON.

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                                  REFERENCES FOR SIGMA+

CORK      60 PR 120 1000         CORK,KERTH,WENZEL,CRONIN,COOL(LRL+PRIN+BNL)
EVANS     60 NC 15 873           BRIST+BRUSS+IAS-U.COL-DUBLIN+LON+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,RINAUDO        (INFN-TURIN)

BEALL     62 PRL 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)

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 NORTON                     (COLUMBIA)

BERLEY    70 PR D1 2015          +YAMIN,HERTZBACH,KOFLER +   (BNL,MASA,YALE)
EBENHOH   70 KIEV CONF           +EISELE,ENGELMANN,FILTHUTH,FOHLISCH+ (HEID)
   ALSO   70 ZPHY 228 151        ANG,EISELE,ENGELMANN,FILTHUTH +       (HEID)
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

                                 PAPERS NOT REFERRED TO IN DATA CARDS

GLASER    58 CERN CONF 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 NOTE PRECEDING LAMBDA MASS LISTINGS

M      3000 1197.47     0.11            SCHMIDT   65 HBC  SEE NOTE N        6/68
M           . . . . . . . . .
M    FIT    1197.34     0.07   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)  1/73*
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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    FIT        7.94     0.09   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)  1/73*
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                 20  (SIGMA-) - (LAMBDA) MASS DIFFERENCE (MEV)

DL   N   SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

DL             81.70     0.19            BURNSTEIN 64 HBC                    9/66
DL       85    81.80     0.24            SCHMIDT   65 HBC  SEE NOTE N        6/68
DL     2279    81.64     0.09            HEPP      68 HBC                    8/68
DL          . . . . . . . . .
DL   AVG       81.666    0.077   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
DL   FIT       81.749    0.067  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  1/73*
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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  BARKAS    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  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        1.484    0.019    0.018  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.6)
                       (SEE IDEOGRAM BELOW )
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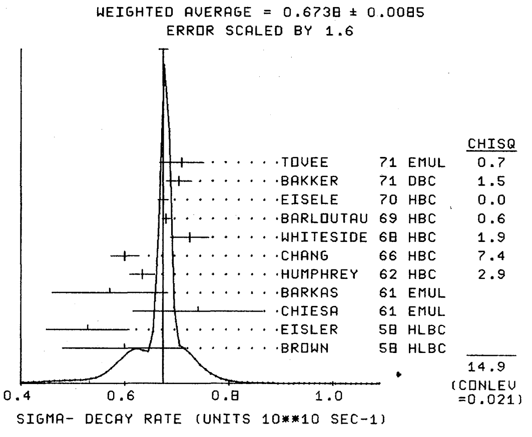

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                 20  SIGMA- PARTIAL DECAY MODES

                                                        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)
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

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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            (1.11)    (0.15)           SECHIZOR   68 HBC     PRELIMINARY     10/68
R2   A  331   (1.02)    (0.08)           ANG 1      69 HBC   - STOP K-         10/69
R2      601    1.09      0.06            EBENHOH    70 HBC     STOP K-         12/70
R2       57    0.97      0.15            COLE       71 HBC     STOP K-         10/71
R2   A   ANG1 REPLACED BY EBENHOH 70.                                           2/71
R2          . . . . . . . . . .
R2   AVG       1.096     0.046   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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          . . . . . . . . . .
R3   AVG       0.604     0.060   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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     P(PI-) LT 110    10/69

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                     20  SIGMA- DECAY PARAMETERS

       RELATED TEXT SECTION IV H 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-   O   OLD RESULTS.  HAVE BEEN REPLACED.
A-   B   BERLEY 70 REPLACED BY BOGERT 70                                        2/71
A-          . . . . . . . . . .
A-   AVG      -0.0688    0.0081  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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)


AV      GV/GA FOR SIGMA TO LAMBDA BETA DECAY (TEXT SEC IV H.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    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*


AV1     GA/GV FOR SIGMA TO NEUTRON BETA DECAY(TEXT SEC IV H.1 FOR SIGN CONV)
AV1      57    (0.05)    (0.23)    (0.32) GERSHWIN  68 HBC  REPLACED BY GER.69   6/68
AV1  C   49     0.23      0.16            COLLERAIN 69 HBC  NEUTRON SCATTER.    10/69
AV1  C   33     0.37      0.26      0.19  EISELE2   69 HBC  NEUTRON SCATTER.   .10/69
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  S         -0.20      0.28            EBENHOH   70 HBC    E- SPECTRUM        3/72
AV1  C   36     0.29      0.28      0.29  BALTAY    72 HBC    NEUTRON SCATTER    6/72*
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  C   COLLERAINE,EISELE,BALTAY MEASURE ABSOLUTE VALUE OF GA/GV.               6/72*
AV1      GERSHWIN 69, BOGERT 70, EBENHOH 70, AND ELLIS 72 MEASURE THE SIGN.
AV1      BUT NEITHER HAS A DEFINITE SIGN DETERMINATION. SINCE THE SIGN IS
AV1      UNDETERMINED THE AVERAGE OF THE SIX VALUES IS MEANINGLESS.
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  S   SIGN CHANGED TO AGREE WITH OUR CONVE. INCLUDES BIERMAN 68 EVENTS.       3/72
AV1           . . . . . . . . . .
AV1 AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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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)
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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)
SECHIZOR 68  TO BE PUBL.        DAY,GLASSER,KNOP+ VIENNA 375      (MARYLAND)
WHITESID 68 NC  54A  537        H. WHITESIDE,J. GOLLUB             (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)
EBENHOH   70 KIEV CONF          +EISELE,ENGELMANN,FILTHUTH,FOHLISCH+ (HEID)
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

                                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    4.99      0.13              SCHMIDT   65 HBC   SEE NOTE N          6/68
D1          . . . . . . . . . .
D1   AVG       4.849     0.069   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D1   FIT       4.863     0.064  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  1/73*

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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          . . . . . . . . . .
DL   FIT      76.89      0.09   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  1/73*

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                        21  SIGMA0 MEAN LIFE (UNITS 10**-14)

T             (1.0)   OR LESS             DAVIS     62 EMUL

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                        21  SIGMA0 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      SIGMA0 INTO LAMBDA GAMMA                       1115+   0
P2      SIGMA0 INTO LAMBDA E+ E-                       1115+  .5+  .5

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                        21  SIGMA0 BRANCHING RATIOS

R1      SIGMA0 INTO(LAMBDA E+ E-)/TOTAL                (P2)/(P1+P2)
R1           (0.00545)   THEORET. CAL. FEINBERG  58        QUANTUM ELECT.    9/66

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                                REFERENCES FOR SIGMA0

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)

                                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 1115.589-M(XI) IS 1322.18 IF M(LAMBDA) IS 1115. 4/68
M     268 1321.12     0.41          WILQUET   72 HLBC                    1/73*
M         . . . . . . . . .
M   AVG   1321.31     0.16    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   FIT   1321.29     0.14   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  1/73*

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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  FIT   1321.29     0.14   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  1/73*

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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    1134  -2.2      0.8           COOL      72 OSPK  - 1.8 GEV/C K-P    1/73*
MM        . . . . . . . . .
MM  AVG     -1.93     0.75    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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   S 2436   (1.637)  (0.050)         COOL      72 OSPK    1.8 GEV/C K-P   1/73*
T     680     1.73     0.08     0.07  MAYEUR    72 HLBC    2.1 GEV/C K-    1/73*
T   S  THE ERROR IS STATISTICAL ONLY
T         . . . . . . . . .
T   AVG       1.672    0.032    0.031  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.1)

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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

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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     4     1.15      0.90     0.55 HUBBARD   68 RVUE
R1      HUBBARD 68 (RVUE) INCLUDES ALL ABOVE EVENTS                       6/68

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

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
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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

R5      XI- INTO (SIGMAO MU- NEUTRINO)/TOTAL                 (P6)
R5            0.005 OR LESS          BERGE     66 HBC                     7/66

R6      XI- INTO (N E- NEUTRINO)/(LAMBDA PI-)                (P7)/(P1)
R6            0.01  OR LESS  CL=.90  BINGHAM   65 RVUE                    9/66

R7      XI- INTO (SIGMAO 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 SIGMAO FROM LAMBDA. THE CABIBBO
R7  D   THEORY PREDICTS SIGMAO RATE ABOUT A FACTOR 6 SMALLER THAN THE
R7  D   LAMBDA.  TO GET A VALUE FOR THE TABLE R7 HAS BEEN AVERAGED WITH R1.

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                  22  XI- DECAY PARAMETERS

        RELATED TEXT SECTION IV H AND APPENDIX III

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    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)               6/68
A   L    LONDON 66 USES ALPHA-LAMBDA = 0.62
A    M   DATA OF MERRILL 68 INCLUDED IN DAUBER 68.
A    O   OLD DATA NOT INCLUDED IN AVERAGE.
A           . . . . . . . . .
A   AVG       -0.403    0.029    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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    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 68 FOR DETAILED DISCUSSION)
F   L    LONDON 66 USES ALPHA-LAMBDA = 0.62
F    M   DATA OF MERRILL 68 INCLUDED IN DAUBER 68.
F    O   OLD DATA NOT INCLUDED IN AVERAGE.
F           . . . . . . . . .
F   AVG       -4.3      8.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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                          REFERENCES FOR XI-

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 B8 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 1272       +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)
COOL     72 PRL 29 1630        +GIACOMELLI,JENKINS,KYCIA,LEONTIC,LI+ (BNL)
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)

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                  23  XIO (1314,JP=1/2 ) I=1/2

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                  23  XIO MASS (MEV)

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   FIT    1314.90     0.55   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  1/73*

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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

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                    23  (XI-) - (XIO) MASS DIFFERENCE (MEV)

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   FIT       6.40     0.55  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  1/73*

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                    23  XIO MEAN LIFE (UNITS 10**-10)

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      469    2.85     0.20     0.18  BRIDGEWAT 72 HBC     1.75 GEV/C K-P     1/73*
T      157    3.04     0.26     0.23  MAYEUR    72 HLBC    2.1 GEV/C K-       1/73*
T            . . . . . . . . .
T   AVG       2.98     0.12     0.11   AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)

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                    23  XIO PARTIAL DECAY MODES

                                                              DECAY MASSES
P1       XIO INTO LAMBDA PIO                                1115+ 134
P2       XIO INTO PROTON PI-                                 938+ 139
P3       XIO INTO PROTON E- NEU                              938+  .5+   0
P4       XIO INTO SIGMA+ E- NEU                             1189+  .5+   0
P5       XIO INTO SIGMA- E+ NEU                             1197+  .5+   0
P6       XIO INTO SIGMA+ MU- NEUTRINO                       1189+ 105+   0
P7       XIO INTO SIGMA- MU+ NEUTRINO                       1197+ 105+   0
P8       XIO INTO PROTON MU- NEUTRINO                        938+ 105+   0

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                    23  XIO BRANCHING RATIOS

R1       XIO INTO (PROTON PI-)/(LAMBDA PIO) (UNITS 10**-3)
R1                                                        (P2)/(P1)
R1            27.0   OR LESS            TICHO     63 HBC                           6/68
R1             5.0   OR LESS            HUBBARD   66 HBC                           6/68
R1             0.9   OR LESS            DAUBER    69 HBC                           6/68

R2       XIO INTO (PROTON E- NEU)/(LAMBDA PIO) (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

R3       XIO INTO (SIGMA+ E- NEU)/(LAMBDA PIO) (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

R4       XIO INTO (SIGMA- E+ NEU)/(LAMBDA PIO) (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

R5       XIO 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

R6       XIO 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

R7       XIO 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                           6/63

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                    23  XIO DECAY PARAMETER

        RELATED TEXT SECTION IV H AND APPENDIX III

A        ALPHA XI 0
A              -0.09     0.46            PJERROU   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   507  (-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    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    ERROR PURELY STATISTICAL                                              1/73*
A            . . . . . . . . .
A   AVG      -0.387     0.090   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                       (SEE IDEOGRAM BELOW )

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   507  (11.2)    (14.4)           BRIDGEWAT 72 HBC     1.75 GEV/C K-P    1/73*
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    ERROR PURELY STATISTICAL                                              1/73*
F            . . . . . . . . .
F   AVG       24.8      20.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                       (SEE IDEOGRAM BELOW )
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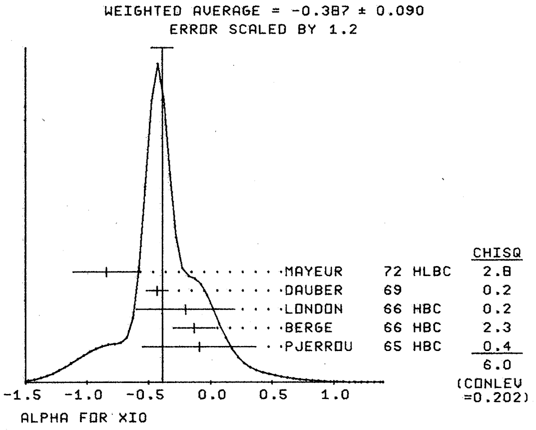

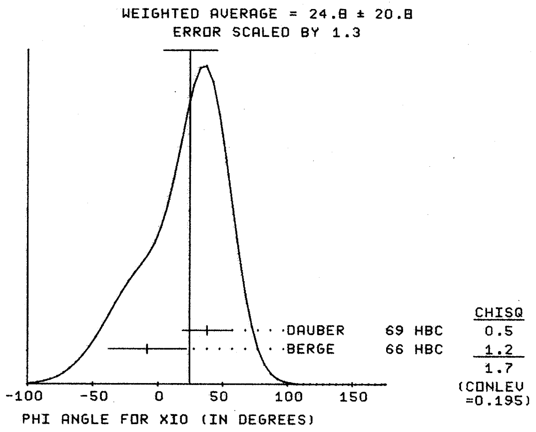

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                               REFERENCES FOR XIO

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)
WILQUET   72 PL 42B 372          +FLIAGINE,GUY,KNIGHT+ (BRUX+CERN+TUFT+LOUC)

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$\boxed{\Omega^-}$

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                        24  OMEGA- (1675,JP=3/2+) I=0
                     QUANTUM NUMBERS ASSIGNED FROM SU3

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                        24  OMEGA- MASS (MEV)

M        1(1620.0)   (25.0)     (10.0) EISENBERG 54 EMUL
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        6 1671.9      1.2             SPETH     69 HBC     K-P 10. GEV/C    11/69
M          . . . . . . . . .
M    AVG   1672.49     0.52     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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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                        24  OMEGA- MEAN LIFE (UNITS 10**-10 SEC)

T    A    1    (1.63)                  ABRAMS    64 HBC                       7/66
T    A    1    (0.7)                   BARNES 1  64 HBC                       7/66
T    A    1    (1.4)                   BARNES 2  64 HBC                       7/66
T    A    1    (1.85)                  COLLEY    65 HBC                       7/66
T    A    1    (1.5)                   RICHARDSO 65 HBC                       7/66
T    A    1    (0.93)                  ABCLV COL 68 HBC                      11/67
T    A    1    (2.6)                   ABCLV COL 68 HBC                      11/67
T    A    1    (1.6)                   ABCLV COL 68 HBC                      11/67
T    A    1    (0.21)                  ABCLV COL 68 HBC                      11/67
T    A    1    (1.20)                  SCHULTZ   68 HBC                      11/67
T    A    1    (0.06)                  SCHULTZ   68 HBC                      11/67
T    A    1    (0.63)                  SCHULTZ   68 HBC                      11/67
T    A    1    (0.25)                  SCOTTER   68 HBC                       6/68
T    A    1    (0.30)                  SCOTTER   68 HBC                       6/68
T    A    1    (0.71)                  SCOTTER   68 HBC                       6/68
T    A    1    (0.08)                  SCOTTER   68 HBC                       6/68
T    A    1    (1.04)                  SCOTTER   68 HBC                       6/68
T    A    1    (2.38)                  SCOTTER   68 HBC                       6/68
T    A   ALLISON INCLUDES ALL ABOVE + 3 MORE BNL EVENTS, UNPUBLISHED.         6/68
T        21     1.31      0.37      0.24 ALLISON   68 RVUE                      6/68
T         1 (2.3)                      SPETH     69 HBC                      10/69
T         1 (0.31)                     SPETH     69 HBC                      10/69

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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

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                        24  OMEGA- BRANCHING RATIOS

R1      OMEGA- INTO LAMBDA K-                              (P1)
R1        2   EVENTS                  PALMER    68 HBC                   11/69
R1        3   EVENTS                  SCHULTZ   68 HBC                   11/69
R1        5   EVENTS  1 AMBIG. XIO PI- SCOTTER  68 HBC                   11/69
R1        6   EVENTS                  SPETH     69 HBC                   11/69

R2      OMEGA- INTO XIO PI-                                (P2)
R2        1   EVENTS                  ABRAMS    64 HBC                   11/69
R2        4   EVENTS                  PALMER    68 HBC                   11/69
R2        3   EVENTS                  SCOTTER   68 HBC                   11/69
R2        1   EVENT                   SPETH     69. HBC                  11/69

R3      OMEGA- INTO XI- PIO                                (P3)
R3        1   EVENT                   PALMER    68 HBC                   11/69
R3        1   EVENT                   SCOTTER   68 HBC                   11/69

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                               REFERENCES FOR OMEGA-

EISENBER 54 PR 96 541          Y EISENBERG                         (CORNELL)
ABRAMS   64 PRL 13 670         + BURNSTEIN,GLASSER +               (UMD+NRL)
BARNES 1 64 PRL  12  204       V E BARNES,CONNOLLY,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)

ABCLV CO 68 NUC PHYS B4 326    AACHEN+BERLIN+CERN+LONDON IMP.COLL.+VIENNA
ALLISON  68 PRIV. COMM.        JOHN ALLISON                      (LANCASTER)
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)

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Data Card Listings

For notation, see key at front of Listings.

Mesons

$\pi^{\pm}$, π^{0}, η, ϵ

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CODE EVENTS QUANTITY  ERROR+  ERROR-  REFERENCE YR TECN SIGN COMMENTS  DATE
     ABOVE                                                          PUNCHED
   BACKGROUND

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$\boxed{\pi^{\pm}}$

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               8  CHARGED PION (140,JPG=0--) I=1
                SEE STABLE PARTICLE DATA CARD LISTINGS

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$\boxed{\pi^{0}}$

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               9  NEUTRAL PION (135,JPG=0--) I=1
                SEE STABLE PARTICLE DATA CARD LISTINGS

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$\boxed{\eta}$

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              14  ETA (549,JPG=0-+) I=0
                SEE STABLE PARTICLE DATA CARD LISTINGS

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$\boxed{\epsilon}$

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              14  PI PI S WAVE, CALLED EPSILON
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S-wave ππ Interactions in the Region 280-1400 MeV

In this note we first discuss the experimental results on the I = 0 ππ S-wave, and thereafter we comment on the possible interpretation.

At threshold, ππ interactions in the $I^G(J^P)C = 0^+(0^+)+$ wave are characterized by a scattering length which still is poorly known (EBEL 71, BASDEVANT 72).

No structure or resonant behavior is indicated near threshold in data from the reaction $\pi N \rightarrow \pi\pi N$. In fact, the only structures claimed in this region are due to reactions involving the nuclei d, H^3, or He^3 (BOOTH 63, HALL 69, BRODY 70, BANAIGS 71), for which the background may be difficult to assess (BRODY 72), and where kinematic reflections from low-mass baryons may contribute (DUBAL 71).

In the region from the ππ threshold (~280 MeV) up to the region near $K\bar{K}$ threshold (~990 MeV), ππ scattering is nearly elastic (BATON 70, CARROLL 72, GRAYER 72, PROTOPOPESCU 72). Up to the ρ meson mass region, δ_0^0 is (qualitatively) uniquely determined; it rises monotonically and reaches a value of 60° to 70° near 700 MeV (SONDEREGGER 69, BATON 70, BAILLON 72, CARROLL 72, FRENKIEL 72, GAIDOS 72, GRAYER 72, PROTOPOPESCU 72).

In the mass region of 700 to 900 MeV, all energy-<u>independent</u> analyses find two solutions ("up-down ambiguity"), with the exception of CARROLL 72 who claim to find only the lower ("down") solution . A possibility of resolving the up-down ambiguity arises from the observation by FLATTE 72, GAIDOS 72, and GRAYER 72 of a very rapid decrease in the S-wave amplitude between 950 and 980 MeV. The size of the observed drop corresponds to a change from nearly the unitarity limit to zero, i.e. to a phase shift change from ~90° to ~180°. This is easily compatible with the "down" solution, which is in the 70° to 90° range between 800 and 900 MeV; in contrast the "up" solution is already near 150° at 900 MeV, and it appears unlikely that it could be smoothly connected with a 90° phase shift at 950 MeV.

In accordance with this, an energy-<u>dependent</u> phase-shift analysis by PROTOPOPESCU 72 using a 2-channel (ππ and $K\bar{K}$) effective range parametrization, gives a (qualitatively) unique I = 0 S-wave phase-shift solution from 550 to 1150 MeV. After having reached 180° near the $K\bar{K}$ threshold, inelasticity sets in and the phase continues to rise slowly. A preliminary analysis by GRAYER 72, as well as the analysis by CARROLL 72, suggests that δ_0^0 may slowly go through 270° somewhere between 1200 and 1400 MeV. (This energy region is however very complicated because the 4π, ρππ, etc. channels are no longer negligible.)

Independent evidence for the correctness of this ("down") solution comes from experiments on $\pi^0\pi^0$ scattering (APEL 72, SKUJA 72). They observe a wide $\pi^0\pi^0$ enhancement at ~800 MeV which is much better described by the "down" solution than by the "up" solution. Futhermore, indirect information from elastic ππ scattering in the crossed channel (NIELSEN 70, ELVEKJAER 71 and 72, HAMILTON 71) is compatible with the "down" but not the "up" solution.

It is clear that the behavior of δ_0^0 is much too complicated to allow a description in terms of one or several Breit-Wigner resonances. We therefore list the positions of the poles of the T matrix, found by searching in the complex energy plane, using the best-fit parameters of the K-matrix or M-matrix. The best fit of PROTOPOPESCU 72 obtains two poles on the second sheet, the $S^*(990)$ and the ε(600). The $S^*(990)$ is connected with the rapid variation of δ_0^0 near the $K\bar{K}$ threshold discussed above, and is also responsible for the large $K\bar{K}$ I = 0 S-wave scattering length. The ε(600) pole is very far from the real axis and therefore much less certain; it is inferred from the large size and slow variation of the S-wave amplitude between 600 and 900 MeV, but PROTOPOPESCU 72 can fit this

Mesons

ε, ρ(770)

Data Card Listings

For notation, see key at front of Listings.

behavior also without an ε pole. Finally, BASDEVANT 72 present a set of ππ amplitudes consistent with crossing, unitarity, and analyticity, and with the ππ phase shifts up to 1100 MeV; their amplitude has a very wide ($\Gamma > 650$ MeV) ε.

We list the S^* parameters separately under S-wave I = 0 $K\bar{K}$ Interactions.

For a recent review see DIEBOLD 72.

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                 14  REAL PART OF POLE POSITION (MEV)

M         (650.0)  OR LESS             BASDEVANT 72 RVUE    SHEET 2            1/73*
M          660.0    100.0              PROTOPOPE 72 HBC     SHEET 2  7. PI+P   1/73*

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                 14  NEGATIVE IMAG. PART OF POLE POSITION (MEV)
                 CORRESPONDS TO HALF WIDTH, NOT FULL WIDTH.

W         (325.0)  OR MORE             BASDEVANT 72 RVUE                       1/73*
W          320.0     70.0              PROTOPOPE 72 HBC     7. PI+ P           1/73*

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REFERENCES FOR EPSILON

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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+ETHZ+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)
SCHARENG 70 NP B 22 16            SCHARENGUIVEL,GUTAY,MILLER,+    (PURD+PENN)
OH        70 PR D 1 2494          +GARFINKEL,MORSE,WALKER,PRENTICE(WISC+TNTO)
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)
EBEL      71 NP B 33 317          +MULLENSIEFEN+    (KARL+CERN+LOUC+RHEL+NIJM)
ELVEKJAE 71  PREPRINT RPP/C22 F.ELVEKJAER,H.NIELSEN            (NORDITA+RHEL)
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)
MORGAN    71  PREPRINT RPP/C30 D.MORGAN                                (RHEL)

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     72 PRL 28 1217          H.BRODY                      (PENNSYLVANIA)
BRODY     72 PRL 28 1215          +GROVES,MAGLICH,NOREM,+    (PENN+RUTG+UPNJ)
CARROLL   72 PRL 28 318           +DIAMOND,FIREBAUGH,MATTHEWS,+   (WISC+TNTO)
DIEBOLD   72  BATAV.CONF.         R.DIEBOLD  RAPPORTEUR TALK            (ANL)
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)
GRAYER    72 PHIL.CONF.PROC. 5 +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
ODORICO   72  PREP.ANL/HEP7204 R.ODORICO                                (ANL)
PRASAD    72 PR D 6 3216          +BREHM             (UNIV.OF MASSACHUSETTS)
PROTOPOP 72 PHIL.CONF.PROC.17 +ALSTON,BARBARO-,FLATTE,FRIEDMAN,+       (LBL)
PROTOPOP 72  LBL 970 SUBM.PR      +LASINSKI,LYNCH,RABIN,SOLMITZ         (LBL)
RISSER    72  PREP.DPH T/72/50 T.RISSER,M.D.SHUSTER                    (SACL)
SKUJA     72  BATAV.CONF.PAPER +WAHLIG,RISSER,PRIPSTEIN,NELSON,+       (LBL)
WHITEHEA 72 NP B 48 365           WHITEHEAD,AULD,+       (AERE+RHEL+SHMP+LOUC)
WILLIAMS 72 PR D 6 3178           P.K.WILLIAMS                          (FSU)
ZYLBERSZ 72 PL 38 B 457           ZYLBERSZTEJN,BASILE,BOURQUIN,+  (GEVA+SACL)

FUJII     73 NC 13 A 311          Y.FUJII,M.KATO                      (TOKYO)
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ρ(770)

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              9  RHO (770, JPG = 1-+) I=1

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              9  RHO MASS (MEV)

M       WE DO NOT LIST ALL VALUES PUBLISHED.WE AVERAGE ONLY                 2/73*
M       THE MOST SIGNIFICANT DETERMINATIONS OF MASS AND WIDTH.              2/73*
M       SOME OF THE RHO 0 DATA MAY BE INFLUENCED BY RHO-OMEGA INTERFERENCE.

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    S      (760.)    (10.)                 ARMENISE  65 HBC   +  2.8 PI+P
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    B      (755.)    (10.)                 ALLES-BOR 67 HBC  +-  5.7 PBAR P      12/66
M    C 7666 (755.0)    (5.0)                BATON     67 HBC   -  2.8 PI- P       10/67
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    S      (777.0)    (7.0)                ABC COLL. 68 HBC   +  8 PI+P TO P+3PI  5/68
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    A    ERRORS ARE 2 STD AND INCLUDE SYSTEMATIC UNCERTAINTIES FROM THEORY
M   X  1300  777.0      5.0                 REYNOLDS  69 HBC   -  2.26 PI- P       1/73*
M   X     SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
M            . . . . . . . . . .
M    AVG     765.9      2.8       AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)

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          (750.0)                         CLARK     65 OSPK   0 1.5 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)                BACON     67 HBC    0 1.7 PI-P         9/67
MO   B  327 (750.)    (10.)                 DANYSZ    67 HBC    0 3.0 PB P,6 PI    7/67
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   S      (770.0)    (3.0)                ABC COLL. 68 HBC    0 8 PI+P TO P+3PI  5/68
MO   R      (775.0)    (2.0)                ARMENISE  68 DBC    0 5.1 PI+D         6/68
MO   B      (745.0)    (5.0)                DONALD    68 HBC    0 1.2 PB P,4 PR.   9/68
MO     1900 (776.)     (5.)                 FOSTER    68 HBC    0 PBAR P AT REST   1/73*
MO     2250  775.0      3.0                 HYAMS     68 OSPK   011.2 PI- P      . 9/68
MO   S      (765.0)    (6.0)                JONES     68 OSPK   0 12PI-, T LT 2.5  5/68
MO   S      (745.0)   (13.0)                JONES     68 OSPK   0 18PI-, T LT 2.5  5/68
MO   S      (760.0)    (5.0)                KEY       68 HBC    0 3.0 PI- P        5/68
MO    13300  766.7      2.8                 PISUT     68 RVUE   0 1.7-3.2PI-,CT10  1/73*
MO   E      (754.0)    (9.0)                AUSLENDER 69 OSPK   0 E+E- COLL.BEAMS  6/68
MO   E       SEE ALSO HAISSINSKI 69, WHO FITS AUSLENDER 69 DATA
MO E         768.      10.                  HAISSINSK 69 RVUE   0 E+E- COLL.BEAMS 12/72*
MO   R      (768.4)    (2.4)                MALAMUD   69 RVUE   0 2-4 PI-P         1/73*
MO   S      (755.0)   (15.0)                MOTT      69 HBC    0 4.1-5.5 K- P     7/69
MO X   1700  772.0      5.0                 REYNOLDS  69 HBC    0 2.26 PI- P       1/73*
MO X      SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
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)                         BATON     70 HBC    0 2.8 PI- P        1/71
MO     140K  767.7      1.9                 BIGGS     70 CNTR   OPHOTOPRODUCTION   1/73*
MO  S       (765.0)    (6.0)                GALLOWAY  70 HBC    0 5.97 PI- P       1/71
MO C         761.0      5.0                 BAILLON   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           775.4      7.3                 BENAKSAS  72 OSPK   0 E+E- COLL.BEAMS  2/72
MO Z 11200   773.5      1.7                 JACOBS    72 HBC    0 2.8 PI- P        1/73*
MO C 32000   775.0      4.0                 PROTOPOPE 72 HBC    0 7.1 PI+P,TCUT.4  1/73*
MO Z   900   764.0      5.0                 RATCLIFF  72 ASPK   0 15. PI- P        1/73*
MO     880   787.0     10.0                 TAKAHASHI 72 HBC    0 8.0 PI- P        1/73*
MO           . . . . . . . . .
MO   AVG     770.3      1.2       AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                              (SEE IDEOGRAM BELOW )
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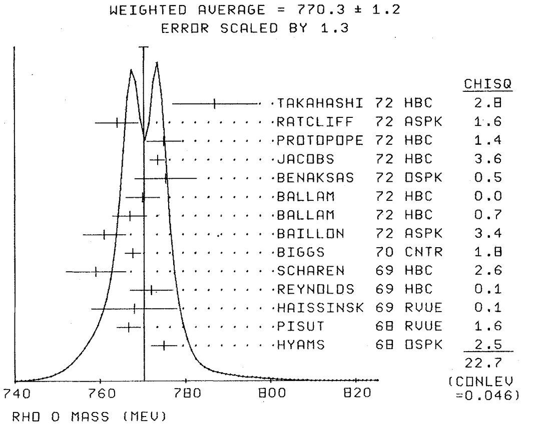
Data Card Listings

For notation, see key at front of Listings.

Mesons

$\rho(770)$



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M         ----------NOTES----------

M    C    FROM POLE EXTRAPOLATION
M    R    INCLUDED IN PISUT 68 RVUE
M    S    S-WAVE BREIT-WIGNER FIT, CANNOT BE COMBINED WITH OTHER VALUES
M    B    HIGH COMBINATORIAL BACKGROUND
M    P    FROM PHOTOPRODUCTION, MODEL DEPENDENT.
M   Z     ERRORS INCREASED BY US. SEE TYPED NOTE ON K* MASS.

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                    9  (RHO0) - (RHO+-) MASS DIFFERENCE (MEV)

D             2.4      2.1              PISUT     68 RVUE     PI N TO RHO N   6/68

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                    9  RHO WIDTH (MEV)

W       SEE NOTE ON RHO MASS 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    S     (160.)     (10.)             ARMENISE  65 HBC   +  2.8 PI+P
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    B     (146.)     (31.)             ALLES-BOR 67 HBC  +-  5.7 PBAR P       12/66
W    C 7666 (110.0)    (9.0)            BATON     67 HBC   -  2.8 PI- P        10/67
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    S     (149.0)    (22.0)            ABC COLL. 68 HBC   +  8 PI+P TO P+3PI   5/68
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   X 1300  154.0     13.0              REYNOLDS  69 HBC   -  2.26 PI- P       1/73*
W   X    SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
W           . . . . . . . . .
W    AVG    147.7      3.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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         (130.0)                      CLARK     65 OSPK   0 1.5 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   S  327 (135.)    (25.)             DANYSZ    67 HBC    0 3.0 PB P,6 PI   1/73*
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   S     (165.0)    (10.0)            ABC COLL. 68 HBC    0 8 PI+P TO P+3PI  5/68
WO   R     (167.0)     (6.0)            ARMENISE  68 DBC    0 5.1 PI+D         6/68
WO   B     (150.0)    (13.0)            DONALD    68 HBC    0 1.2 PB P,4 PR.   9/68
WO     1900 (132.)    (10.)             FOSTER    68 HBC    0 PBAR P AT REST  1/73*
WO Z  2250  145.0     12.0              HYAMS     68 OSPK   011.2 PI- P     . 1/73*
WO   S     (129.0)    (19.0)            JONES     68 OSPK   0 12PI-, T LT 2.5  5/68
WO   S     (169.0)    (41.0)            JONES     68 OSPK   0 18PI-, T LT 2.5  5/68
WO   S     (113.0)    (16.0)            KEY       68 HBC    0 3.0 PI- P        5/68
WO   P     (160.0)    (10.0)            LANZEROTT 68 CNTR   0 GAMMA P         1/73*
WO   C14890 (105.0)   (15.0)            MARATECK  68 HBC    0 1.9-3.0 PI- P    9/68
WO   E     (105.0)    (20.0)            AUSLENDER 69 OSPK   0 E+E- COLL.BEAMS  6/68
WO   E      SEE ALSO HAISSINSKI 69, WHO FITS AUSLENDER 69 DATA
WO E        140.      14.               HAISSINSK 69 RVUE   0 E+E- COLL.BEAMS 12/72*
WO   R     (132.0)    (13.0)            MALAMUD   69 RVUE   0 2-4 PI-P        1/73*
WO   S     (130.0)    (40.0)            MOTT      69 HBC    0 4.1-5.5 K- P     7/69
WO X  1700  135.0     16.0              REYNOLDS  69 HBC    0 2.26 PI- P      1/73*
WO X    SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
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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   OPHOTOPRODUCTION   1/73*
WO  S      (120.0)    (7.0)             GALLOWAY  70 HBC    0 5.97 PI- P       1/71
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          149.6     23.2              BENAKSAS  72 OSPK   0 E+E- COLL.BEAMS 12/72*
WO   11200 (178.35)   (2.5)             JACOBS    72 HBC    0 2.8 PI- P        1/73*
WO C 32000  160.0     10.0              PROTOPOPE 72 HBC    0 7.1 PI+P,TCUT.4  1/73*
WO Z   900  157.0     21.0              RATCLIFF  72 ASPK   0 15. PI- P        1/73*
WO Z   880  144.0     19.0              TAKAHASHI 72 HBC    0 8.0 PI- P        1/73*
WO          . . . . . . . . . .
WO  AVG     146.0      2.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W         ----------NOTES----------

W    C    FROM POLE EXTRAPOLATION
W    R    INCLUDED IN PISUT 68 RVUE
W    S    S-WAVE BREIT-WIGNER FIT, CANNOT BE COMBINED WITH OTHER VALUES
W    B    HIGH COMBINATORIAL BACKGROUND
W    P    FROM PHOTOPRODUCTION, MODEL DEPENDENT.
W   Z     ERRORS INCREASED BY US. SEE TYPED NOTE ON K* MASS.

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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       RHO0 INTO PI+ PI- PI0 (VIOLATES G)                139+ 139+ 134

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                    9  RHO BRANCHING RATIOS

R1       RHO INTO 4PI/2PI                                  (P2)/(P1)

R1       RHO+- INTO (PI+- PI+ PI- PI0) / (PI+- PI0)
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   HUSON     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                             (P3)/(P1)
R2   M         (0.02) OR LESS           LANZEROTT 65 CNTR     GAMMA P(BREMS)   11/66
R2             (0.005)OR LESS  CL=.97   FIDECARO  66 OSPK  -                   10/66
R2             (0.007)OR LESS           HUSON     66 HLBC  -  15 PI-PB          6/66
R2   M         (0.002)OR LESS  CL=.90   GERMAN CO 69 HBC
R2   M          ONE PION EXCHANGE MODEL USED IN THIS ESTIMATION
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Note on $\rho^0 \rightarrow e^+e^-$

Extraction of a ratio for $\rho^0 \rightarrow e^+e^-$ is complicated by interference with ω^0 decay. In photoproduction, $\gamma A \rightarrow e^+e^-A$, there is substantial interference between the allowed $(\rho^0, \omega) \rightarrow e^+e^-$ decays. The interference in the colliding-beam reaction $e^+e^- \rightarrow \pi^+\pi^-$ is due to G parity violating mixing of the overlapping ρ^0 and ω resonances; it alters the results for the rate $\Gamma(\rho^0 \rightarrow e^+e^-)$ only by a small amount. Therefore we use at present, for the average, only the values from the $e^+e^- \rightarrow \pi^+\pi^-$ experiments.

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R3      RHO INTO(E+ E-)/(PI+PI-) (UNITS 10**-4)            (P4)/(P1)
R3   P   94   (0.65)   (0.14)          ASBURY 1  67 CNTR     PHOTOPRODUCTION  9/67
R3   P         POSSIBLY LARGE RHO-OMEGA INTERFERENCE
R3   H        (0.65)   (1.1)    (0.5)  HERTZBACH 67 OSPK ASSUME SU(3)+MIXING.10/66
R3   H         NOT SEPARATED FROM OMEGA DECAY.
R3   A   33   (0.53)   (0.11)          ASTVACATU 68 OSPK ASSUME SU(3)+MIXING  6/68
R3   A         NOT SEPARATED FROM OMEGA DECAY. ERROR STATISTICAL ONLY.
R3    E       (0.663)  (0.085)         AUGUSTI1  69 OSPK    E+E- COLLID.BEAM  4/69
R3    E        ASSUMING RHO WIDTH 111 MEV
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   F         ASSUMING RHO WIDTH 140 MEV. ERROR STATISTICAL ONLY.
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)

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
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R5     RHO INTO (MU+ MU-)/(PI+ PI-) (UNITS 10**-4)       (P6)/(P1)
R5
R5              SEE NOTE UNDER RHO INTO E+E- ABOVE
R5
R5   H          0.97     0.31     0.33  HYAMS     67 OSPK    11 PI- LI H       6/67
R5   H          HYAMS MASS RESOL. IS 20 MEV. THE OMEGA REGION WAS EXCLUDED.
R5   R          0.82     0.16     0.36  ROTHWELL  69 CNTR    PHOTOPRODUCTION . 4/70
R5   R          POSSIBLY LARGE RHO-OMEGA INTERFERENCE LEADS US TO INCREASE
R5   R          THE MINUS ERROR
R5              0.56     0.15           WEHMANN   69 OSPK    12 PI- ON C,FE    7/69
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.
R5           . . . . . . . . .
R5   AVG        0.67     0.12    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6     RHO 0 INTO (PI+ PI- PI0)/(PI+ PI-)                (P7)/(P1)
R6   G        (0.01) OR LESS  CL=.84   ABRAMS     71 HBC    0 3.7 PI+ P       11/71
R6   G      MODEL DEPENDENT,ASSUMES I = 1,2,OR 3 FOR THE 3PI SYSTEM           11/71

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REFERENCES FOR RHO

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ANDERSON 61 PRL 6 365          ANDERSON,BANG,BURKE,CARMONY,SCHMITZ   (LRL)
ERWIN    61 PR 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)
XUONG    62 PR 128 1849        NGUYEN HUU XUONG,GERALD R LYNCH       (LRL)

ABOLINS  63 PRL 11 381         ABOLINS,LANDER,MEHLHOP,NGUYEN,YAGER  (UCSD)
ALITTI   63 NC 29 515          ALITTI,BATON,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 + BOLOGNA- 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 SCHIAVON    (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+BONN)
ASBURY 1 67 PRL 19 869         +BECKER+BERTRAM+JOOS+JORDAN+    (DESY+COLU)
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+COEF+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        +JOHNSON+KLEIN+PETERS+SAHNI+YEN+     (PURDUE)
FRENCH   67 NC 52A 442         +KINSON+MCDONALD+RIDDIFORD+     (CERN+BIRM)
HERTZBAC 67 PR 155  1461       HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
   ALSO  65 ZDANIS
HUWE     67 PL 24B 252         +MARQUIT+OPPENHEIMER+SCHULTZ+WILSON  (COLU)
HYAMS    67 PL 24B 634         +KOCH+PELLETT+POTTER+VONLINDERN+(CERN+MPIM)
MILLER   67 PR 153 1423        MILLER,GUTAY,JOHNSON,LOEFFLER +     (PURDUE)
POIRIER  67 PR 163 1462        +BISWAS,CASON,DERADO,KENNEY+    (NDAM+PENN)

ABC COLL 68 NP B4 501                 AACHEN+BERLIN+CERN COLLABORATION
ARMENISE 68 NC 54A 999         +GHIDINI,FORINO+       (BARI+BGNA+FIRZ+ORSAY)
ASTVACAT 68 PL 27 B  45        ASTVACATUROV,AZIMOV,BALDIN+   (JINR+MOSCOW)
BATON    68 PR 176 1574        J.P. BATON, 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+COEF)
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,PANTUSOVA,PESTOV+    (NOVO)
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+COLO)
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  PREPRINT          BLOODWORTH,JACKSON,PRENTICE,YOON  (TORONTO)
DEERY    71 PR D 3 635         +BISWAS,CASON,GROVES,JOHNSON,+ (NOTRE DAME)
DRIVER   71  DESY 71/56        +HEINLOTH,HOHNE,HOFMANN,JANATA,KAROW+(DESY)
EISENBER 71  SLAC-PUB-933      EISENBERG,HABER,BALLAM,CHADWICK+(REHO+STAN)

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.CONF.PROC. 5 +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
GRAYER   72 NP B 50 29         +HYAMS,JONES,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)
PROTOPOP 72  PREPRINT LBL-970 PROTOPOPESCU,ALSTON,BARBARO,FLATTE,+  (LBL)
TAKAHASH 72 PR D 6 1266        TAKAHASHI,BARISH,+    (TOHO+PENN+NDAM+ANL)
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ω(784)

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            1  OMEGA (784,JPG=1--) I=0

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            1  OMEGA MASS (MEV)

         HERE WE LIST ONLY EXPERIMENTS IN WHICH THE EFFECTS
         OF MASS RESOLUTION HAVE BEEN EVALUATED.

M       FROM FINAL STATE K1 K1 OMEGA
M      64  779.4      1.4            ARMENTERO 62 HBC      0.0 PBAR P K1K1
M     155  779.5      1.5            BARASH    67 HBC      0.0 PBAR P K1K1 11/71
M     510  781.0      0.6            BIZZARRI  71 HBC      0.0 P PBAR K1K1 11/71
M          . . . . . . . . .
M   AVG    780.60     0.52    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M       FROM OTHER FINAL STATES
M     400  782.0      1.0            ALFF      62 HBC      2.3-2.9 PI+P
M      34  784.0      1.0            ARMENTERO 63 HBC      0.0 PBAR P
M     220  781.0      2.0            KRAEMER   64 DBC      1.2 PI+D
M          785.6      1.2            MILLER D  65 HBC     SEEN WITH K+K-
M     666  786.0      1.0            JAMES     66 HBC      2.1 PI+P           6/66
M    2198  783.4      0.7            BALTAY    67 HBC     0.0 PBAR P          9/66
M          784.8      1.1            KEY       68 HBC      3 PI-P            11/67
M    2400  782.4      0.5            BIZZARRI  69 HBC      0 PBAR P           9/69
M     250  784.       1.             DANBURG   70 DBC      1.2 PI+ D         11/71
M     500  786.       1.             DANBURG   70 DBC      1.4 PI+ D         11/71
M     600  784.       1.             DANBURG   70 DBC      1.7 PI+ D         11/71
M     500  786.       1.             DANBURG   70 DBC      1.9 PI+ D         11/71
M     400  785.       1.             DANBURG   70 DBC      2.1 PI+ D         11/71
M     200  785.       2.             DANBURG   70 DBC      2.3 PI+ D         11/71
M     750  784.1      1.2            ABRAMOVIC 70 HBC      3.9 PI- P          6/70
M          784.0      0.7            ATHERTON  70 HBC     3.6 PBAR P, 7 PI    5/70
M          783.2      1.6            BIGGS     70 CNTR    PHOTOPRODUCTION     6/70
M     260  781.0      2.0            CASON     70 HBC      8.0 PI-P,4PI
M     248  783.4      1.0            BIZZARRI  71 HBC      0.0 P PBAR K+K-  11/71
M   C 4270 (784.1)    (0.3)          COYNE     71 HBC     3.7 PI+ P          11/71
M   C      FROM TOTAL SAMPLE OF COYNE 71                                     11/71
M  D       783.7      1.0            COYNE     71 HBC     3.7 PI+ P          11/71
M  D       FROM BEST-RESOLUTION SAMPLE OF COYNE 71                           11/71
M     369  784.0      1.4            MATTHEWS  71 DBC      6.95 PI+ D         2/71
M     418  782.5      0.8            AGUILAR   72 HBC     3.9,4.6 K- P      12/72*
M          . . . . . . . . .
M   AVG    783.76     0.28    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                              (SEE IDEOGRAM BELOW )
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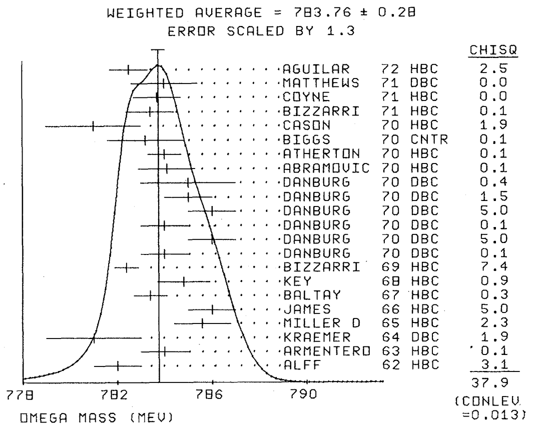

Data Card Listings

For notation, see key at front of Listings.

Mesons

ω(784)

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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  B  171    (5.8)    (2.8)         BARASH    67 HBC     0.0 PBAR P,K1 K1 11/71
W  B         UNFOLDED BY COYNE 71                                         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  E  940     7.70     1.65         BROWN     72 MMS     2.5 PI- P,N MMS  12/72*
W  E     ERROR TAKES ACCOUNT OF SYSTEMATICS ADDED LINEARLY
W              . . . . . . . . . .
W   AVG       9.84     0.51     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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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 (ONLY NEUTRAL INPUT TO FIT) 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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<u>FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS</u>

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The <u>diagonal</u> elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the <u>off-diagonal</u> elements are the <u>normalized</u> 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 .8961+-.0058
 P 2   -.3543  .0130+-.0027
 P 3   -.9269    -.0226  .0909+-.0050


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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  FIT        0.1015   0.0067 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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 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  F          FLATTE 70 SEES NO SIGNAL AT 1.7, 2.1, 2.6 GEV/C.
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 R           ROOS 70 COMBINES ABRAMOVICH 70 AND BIZZARRI 70
R2             0.028    0.006          BEHREND   71 ASPK   PHOTOPRODUCTION  11/71
R2            (0.0015)OR MORE CL=.95   HAGOPIAN  71 HBC     2.3 PI- P        1/71
R2 S           0.021    0.028    0.009 RATCLIFF  72 ASPK  15.PI- P,N 2PI    12/72*
R2 S    SIGNIFICANT INTERFERENCE EFFECT OBSERVED.NB OF OMEGA INTO 3PI       12/72*
R2 S    COMES FROM AN EXTRAPOLATION.                                        12/72*
R2          . . . . . . . . . .
R2  AVG        0.0259   0.0049  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  FIT        0.0145   0.0031 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

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          . . . . . . . . . .
R3  AVG        0.097    0.015   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  FIT        0.1015   0.0067 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R4      OMEGA INTO (PI+ PI- GAMMA)/(PI+ PI- PIO)        (P4)/(P1)
R4            (0.05) OR LESS           FLATTE    66 HBC     1.8 K-P          9/66

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           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*

R8      OMEGA INTO (ETA PIO + ETA GAMMA)/(PI+ PI- PIO)  (P9+P6)/(P1)
R8            (0.017)OR LESS           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        0.1000   0.0067 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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 B          MASS RESOLUTION OF BINNIE 65 IS ABOUT 15 MEV.
R13 H         (1.0)    (1.7)    (0.75) HERTZBACH 67 OSPK ASSUME SU(3)+MIXING.10/66
R13 H          NOT RESOLVED  FROM RHO DECAY.
R13 A    33   (0.65)   (0.13)          ASTVACATU 68 OSPK ASSUME SU(3)+MIXING  6/68
R13 A          NOT RESOLVED  FROM  RHO  DECAY. ERROR STATISTICAL ONLY.
R13            0.40     0.21           BOLLINI1  68 CNTR    1.7PI-P,NOTE Z   9/68
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.
R13 E         (0.76)   (0.14)          AUGUSTI1  69 OSPK    SEE NOTE E       2/72
R13 E  FROM E+ E- COLLIDING BEAMS, ASSUMING OMEGA WIDTH 12.2+-1.3 MEV         4/69
R13            0.83     0.10           BENAKSAS1 72 OSPK   E+E- COLL.BEAMS   2/73*
R13         . . . . . . . . . .
R13 AVG        0.76     0.17    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)

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 FIT        0.0909   0.0055 FROM FIT 'ERROR INCLUDES SCALE FACTOR OF 1.1)

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            0.0080   0.0028   0.0022BIGGS     70 CNTR    PHOTOPRODUCTION   6/70
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         . . . . . . . . . .
R15 AVG        0.0102   0.0019  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R15 FIT        0.0130   0.0027 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

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     11/71
R18 D       PIO GAMMA AS THE ONLY NEUTRAL DECAY.                             11/71

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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,BUNIATOV+      (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.CONF.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+NAL)
BIZZARRI  71 NP B 27 140          +MONTANET,NILSSON,D-ANDLAU,+    (CERN+CDEF)
BLOODWOR  71 NP B 35 133          BLOODWORTH,JACKSON,PRENTICE,YOON  (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+OXF)
HAGOPIAN  71  BAPS 16             S.HAGOPIAN                        (FSU+PENN)
LEFRANCO  71  PREPRINT LAL1256 J.LEFRANCOIS                            (ORSAY)
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.CONF.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)

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M(940) →MM

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                        66  M(940)

                        EVIDENCE NOT COMPELLING.OMITTED FROM TABLE.

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                        66  M(940) MASS  (MEV)

M  N    55  940.5      1.7            CHESHIRE   72 MMS   0 2.4 PI- P,N MM   12/72*
M  N    NOT SEEN BY BINNIE 72 AT THRESHOLD.

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                        66  M(940) WIDTH  (MEV)

W  N    55  (10.4)  OR LESS  CL=.90   CHESHIRE   72 MMS   0 2.4 PI- P,N MM   12/72*

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                        66  M(940) BRANCHING RATIOS

R1     M(940) INTO (NEUTRAL)/(TWO-CHARGE)/(FOUR-CHARGE)
R1             0.12      0.86      0.02   CHESHIRE   72 MMS   0 2.4 PI- P,N MM   12/72*

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                             REFERENCES FOR M(940)

CHESHIRE 72 PRL 28 520          +HOFFMAN,GARFINKEL,+          (IOWA+ANL+PURD)
BINNIE   72 PL 39 B 275         +CAMILLERI,DUANE,GARBUTT,BURTON+(LOIC+SHMP)

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M(953) $\to\gamma\pi^+\pi^-$ $\not\to\gamma\rho^0$

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                      59  M (953,JPG=  +)

                              WHILE MASS AND WIDTH ARE CONSISTENT WITH THOSE OF
                              THE ETA PRIME(958), THE (PI+ PI- GAMMA) DECAY DOES
   NOT SHOW A RHOO SIGNAL, UNLIKE THE ETA PRIME. THIS IS TAKEN AS EVIDENCE
   FOR A NEW PARTICLE. WHILE THIS DIFFERENCE IN DALITZ PLOT DISTRIBUTIONS
   APPEARS SIGNIFICANT, IT STILL NEEDS FURTHER CONFIRMATION TO BE REGARDED
   AS WELL ESTABLISHED. POSSIBLY SEEN IN MMS .
                              OMITTED FROM TABLE.

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                      59  M MASS (MEV)

M       68  953.0      2.0              AGUILAR   70 HBC     3.9-4.6K-P,P K-M  1/71
M   M     (953.4)    (1.5)     (3.8)   MAGLICH   71 MMS     3.8 P D,HE3 XO    2/72
M   M   MISSING MASS SPECTRUM SHOWED THIS PEAK AT 953.4 INSTEAD OF
M   M   ETA PRIME (958).  PEAK LISTED UMDER M BECAUSE OF MASS
M   M   COINCIDENCE.  THE 1.5 MEV ERROR MAY BE UNDERESTIMATED BY
M   M   A FACTOR OF 2 (SEE BRODY 72, TABLE III).  OBSERVED PEAK COULD
M   M   THEN WELL CORRESPOND TO ETA PRIME.

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                      59  M WIDTH (MEV)

W       68  (10.0)  OR LESS  CL=.95   AGUILAR    70 HBC      3.9-4.6K-P,P K-M  1/71
W   M        (15.)  OR LESS           MAGLICH    71 MMS      3.8 P D,HE3 XO    2/72

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                      59  M PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      M INTO PI+ PI- GAMMA                             139+ 139+   0
P2      M INTO RHOO GAMMA                                770+   0
P3      M INTO PI+ PI- ETA                               139+ 139+ 548
P4      M INTO PIO ETA                                   134+ 548
P5      M INTO PI+ PI- PIO                               139+ 139+ 134

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                      59  M BRANCHING RATIOS

R1      M INTO (RHOO GAMMA)/(ALL PI+ PI- GAMMA)          (P2)/(P1)
R1       58    0.05      0.1          AGUILAR    70 HBC      3.9-4.6K-P,P K-M  1/71

R2      M INTO (PI+ PI- GAMMA)/(PI+ PI- ETA NEUTR.)      (P1)/(P3N)
R2       58    1.2       0.3          AGUILAR    70 HBC      3.9-4.6K-P,P K-M  1/71

R3      M INTO (PI+ PI- PIO)/TOTAL                       (P5)
R3       58    NOT OBSERVED           AGUILAR    70 HBC      3.9-4.6K-P,P K-M  1/71

R4      M INTO (PIO ETA NEUTR.)/TOTAL                    (P4N)
R4       58    NOT OBSERVED           AGUILAR    70 HBC      3.9-4.6K-P,P K-M  1/71
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                             REFERENCES FOR M

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)
BRODY     72 UPR-3E.SUBM.TO PR +GROVES,NOREM,CVIJANOVICH,+(PENN+RUTG+UPNJ)

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$\eta'(958)$

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              2  ETA PRIME (958,JPG=0-+) I=0

                 KNOWN ALSO AS XO
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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 a $\eta' \to \gamma\gamma$ 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. However, various attempts to find evidence for a spin different from zero, by searching for anisotropies in η' decay, were unsuccessful. The most complete study was made by DANBURG 72 with about 1000 η' decays from the reaction $K^-p \to \eta'\Lambda$ at 2.2 GeV/c. This number of events was sufficient to make cuts on momentum transfer and Λ polarization angle. No η' decay anisotropies or correlations were found. This is rather suggestive evidence that the η' spin is indeed zero. Presumably an Adair-type analysis could be used to settle this question unambiguously.

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                      2  ETA PRIME MASS (MEV)

M   O   ONLY EXPERIMENTS GIVING ERROR LESS THAN 3 MEV KEPT FOR AVERAGING    12/72*
M       85 (957.0)                    DAUBER     64 HBC       1.95 K-P
M   K      (958.0)    (1.0)           KALBFLEIS  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        8  960.0      2.0            TRILLING   65 HBC       3.65 PI+ P       9/66
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           956.0      2.0            AGUILAR    70 HBC      3.9-4.6K-P        1/71
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           958.4      0.3            DANBURG    72 HBC      2.2 K- P,L XO    12/72*
M           . . . . . . . . .
M   AVG     958.11     0.37    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                               (SEE IDEOGRAM BELOW )
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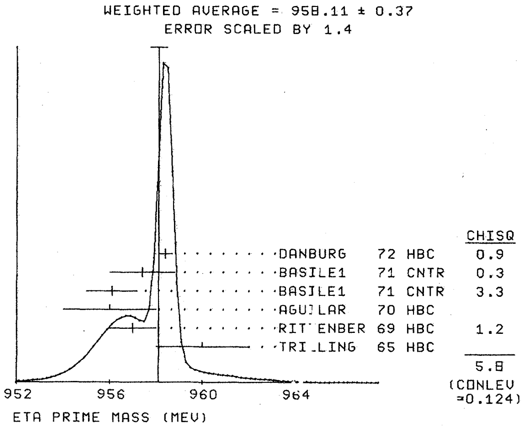

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                    2  ETA PRIME WIDTH (MEV)

W        85   (4.0)   OR LESS              DAUBER     64 HBC     1.95 K-P
W   K         (7.0)   OR LESS              KALBFLEIS 64 HBC      2.7 K-P            6/66
W   K              KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69
W            (30.0)   OR LESS              BADIER     65 HBC     3.0 K-P
W            (15.0)   OR LESS              LONDON     66 HBC     2.2 K-P            6/66
W            (10.)    OR LESS              RITTENBER 69 HBC      1.7-2.7 K- P
W            (20.0)   OR LESS              AGUILAR    70 HBC     3.9-4.6K-P         1/71
W      3415   (8.)    OR LESS   CL=.90     BASILE1    71 CNTR    1.6 PI- P,N X0    11/71
W             (3.8)   OR LESS   CL=.90     DANBURG    72 HBC     2.2 K- P,L X0    12/72*
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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 PI0 PI0 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
P6      ETA PRIME INTO RHO0 GAMMA                            0+ 770
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 PI0 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 PI0 RHO 0 (VIOLATES C)              134+ 770
P19     ETA PRIME INTO PI0 OMEGA (VIOLATES C)              134+ 783
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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 1 .4719+-.0342
P 2   -.3506   .2465+-.0207
P 3   -.6026      -.5278   .2622+-.0350
P 4    .0217      -.1663      .0036   .0194+-.0029
```

Note on η' (958) Branching Fractions

In our calculation of the branching fractions of the η' (958) we assume the decay modes $\eta\pi\pi$ (including $\eta\pi^0\pi^0$, 71% of the η's have neutral decays), $\rho^0\gamma$, and $\gamma\gamma$.

In the fit we do not use the constraint

$$R = \Gamma(\eta' \to \eta\pi^+\pi^-)/\Gamma(\eta' \to \eta\pi^0\pi^0) = 2$$

from I-spin conservation. The result of the fit is in agreement with it, $R = 1.9 \pm 0.2$.

```
                    2  ETA PRIME BRANCHING RATIOS

R1       ETA PRIME INTO (PI+ PI-ETA (NEUTRAL DEC.))/TOTAL (PIN)
R1   K   68   (0.36)    (0.05)            KALBFLEIS 64 HBC      2.7 K-P            10/66
R1   K             KALBFLEISCH 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       0.336     0.024  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.0)

R2       ETA PRIME INTO (PI+ PI- NEUTRALS) / TOTAL          (P1N+P2C)
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   FIT       0.407     0.023  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)

R3       ETA PRIME INTO (PI+ PI- ETA (CHRGD.DECAY))/TOTAL (PIC)
R3   K   44   (0.12)    (0.02)            KALBFLEIS 64 HBC      2.7 K-P            10/66
R3   K             KALBFLEISCH 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   FIT       0.1364    0.0099 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.0)

R4       ETA PRIME INTO (PI+ PI- NEUTRALS (EXCLUDING        (P2C)
R4            PI+ PI- ETA (NEUTR.DEC.))) / TOTAL
R4   K   10   (0.05)    (0.04)            KALBFLEIS 64 HBC      2.7 K-P            10/66
R4   K             KALBFLEISCH 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       0.0712    0.0060 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5       ETA PRIME INTO (NEUTRALS) / TOTAL                  (P2N+P4)
R5   K   54   (0.25)    (0.05)            KALBFLEIS 64 HBC      2.7 K-P            10/66
R5   K             KALBFLEISCH 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 X0     11/71
R5             . . . . . . . . .
R5   AVG       0.190     0.016   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5   FIT       0.195     0.025  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)

R6       ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/TOTAL
R6                                                          (P3)
R6   K   42   (0.22)    (0.04)            KALBFLEIS 64 HBC      2.7 K-P            10/66
R6   K             KALBFLEISCH 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   FIT       0.262     0.035  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.2)

R7       ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/(PI PI ETA)
R7                                                          (P3)/(P1+P2)
R7             0.25      0.14             DAUBER     64 HBC     1.95 K-P           10/66
R7             . . . . . . . . .
R7   FIT       0.365     0.065  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.1)

R8       ETA PRIME INTO (PI0 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 (PI0 RHO0)/TOTAL                    (P18)
R10           (0.04) OR LESS              RITTENBER 65 HBC            2.7 K-P      10/66

R11      ETA PRIME INTO (PI0 OMEGA) /TOTAL                  (P19)
R11           (0.08) OR LESS              RITTENBER 65 HBC            2.7 K-P      10/66

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              LONDON     66 HBC     COMPILATION        10/66

R18      ETA PRIME INTO (RHO0 GAMMA)/(PI PI ETA)            (P6)/(P1+P2)
R18            0.31      0.15             DAVIS      68 HBC      5.5 K- P           9/68
R18            . . . . . . . . .
R18 FIT        0.365     0.065  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.1)

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 S    41   (0.017)   (0.004)         BASILE2    71 CNTR    1.6 PI- P,N X0     12/72*
R19 S    SUPERSEDED BY DALPIAZ 72
R19      31    0.020     0.008    0.006 HARVEY     71 OSPK    3.65 PI- P,N X0    11/71
R19      68    0.0171    0.0033         DALPIAZ    72 CNTR    1.6 PI- P,N X0     12/72*
R19            . . . . . . . . .
R19 AVG        0.0181    0.0030   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R19 FIT        0.0194    0.0029 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

R21      ETA PRIME INTO (PI+PI-PI0)/TOTAL                   (P12)
R21           (0.05) OR LESS              RITTENBER 69 HBC      1.7-2.7 K-P         9/69

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

R23      ETA PRIME INTO (PI+PI+PI-PI-PI0)/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       (P16+...)
R24           (0.01) OR LESS              RITTENBER 69 HBC      1.7-2.7 K-P         9/69

R25      ETA PRIME INTO (RHO0 GAMMA)/(ALL PI+ PI- GAMMA)    (P6)/(P3)
R25            0.94      0.20             AGUILAR    70 HBC     3.9-4.6K-P          1/71
R25           (1.1)     (0.1)             DANBURG    72 HBC     2.2 K- P,L X0      12/72*
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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       0.0739   0.0062 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R27     ETA PRIME INTO (PI+ PI- GAMMA)/(PI+ PI- ETA(NEUTRAL DEC.))
R27                                                  (P3)/(P1N)
R27           0.54     0.10           AGUILAR   72 HBC    3.9,4.6 K- P     12/72*
R27          (0.81)   (0.09)          DANBURG   72 HBC    2.2 K- P,L X0  . 2/73*
R27           . . . . . . . . .
R27 FIT       0.78     0.15  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)

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       0.111    0.054  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.8)


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                       REFERENCES FOR ETA PRIME

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)
KALBFLEI 64 PRL 13 349          G.R.KALBFLEISCH,O.DAHL,A.RITTENBERG   (LRL)JP

BADIER   65 PL 17 337           BADIER,DEMOULIN,BARLOUTAUD+(EPOL+SACL+ZEEM)
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,+      (ETHZ+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 25 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)
DANBURG  72 PHIL.CONF.PROC.     +BORENSTEIN,KALBFLEISCH,CHAPMAN,+(BNL+MICH)
RADER    72 PR D 6 3059         +ABOLINS,DAHL,DANBURG,DAVIES,HOCH,+   (LBL)

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δ(970) →ηπ,···

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36  DELTA(970,JPG=0+-) I=1
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Under this entry, we list three types of I = 1 peaks near $K\bar{K}$ threshold.

1) Missing-mass peaks, some of them controversial.
2) $\eta\pi$ decays, peaking slightly below $K\bar{K}$ threshold. This defines $I^G = 1^-$ and J^P = Normal.
3) Threshold enhancements in the $(K\bar{K})^{\pm}$ system with I = 1. The Q value is low and J^P therefore probably 0^+.

In listing them together under a common entry we do not imply that they are necessarily all related. However, the $K\bar{K}$ threshold enhancement may be due to a virtual bound state that could also be responsible for the $\eta\pi$ peaks (ASTIER 67). More complete studies of the mass dependence of the $K\bar{K}$ threshold effect, using coupled channel analysis, are needed to clarify this question.

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                     36  DELTA(970) MASS  (MEV)

M  PEAKS SEEN IN MISSING MASS EXPERIMENTS
M   K  262 (962.0)    (5.0)         KIENZLE   65 MMS   -  3-5 PI- P        9/66
M   K   NOT SEEN BY BANNER1 67 (1.8 PI- P)
M   O      (966.0)    (8.0)         OOSTENS   66 MMS   +  3.8 PP TO D + MM 9/66
M   O   NOT SEEN BY BANNER2 67 AND ANDERSON 71
M           975.0      6.0          ABOLINS   70 MMS   +  3.8-6.3 PP--D+MM 1/71
M   N  215 (962.9)    (1.7)         CHESHIRE  72 MMS   0 2.4 PI- P,N MM   12/72*
M   N   NOT SEEN BY BINNIE 72 AT THRESHOLD.

M  ETA PI FINAL STATE ONLY.
M  S    30  980.0     10.0          AMMAR     68 HBC  +-    ,5.5K-,ETA PI  2/73*
M  S    SEE ALSO AMMAR 70.
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  3/69
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    2/72
M      150  972.      10.           DEFOIX    72 HBC  +- 0.7 PBAR P,7 PI   1/73*
M           . . . . . . . . . .
M   AVG     965.8      7.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                     (SEE IDEOGRAM BELOW )
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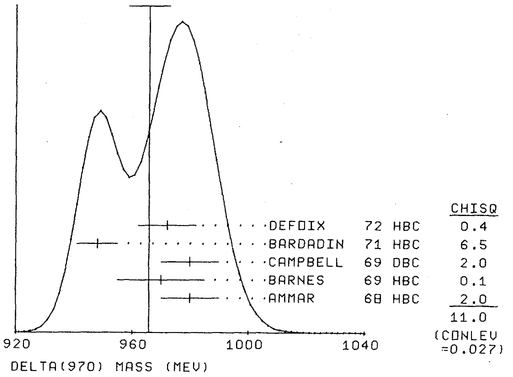
WEIGHTED AVERAGE = 965.8 ± 7.1
ERROR SCALED BY 1.7



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M  K KBAR ONLY, SEE THE TYPED NOTE ABOVE
M     143(1003.3)     7.0+SYSTEMATIC ROSENFELD 65 RVUE +-                . 8/66
M          SCAT. LENGTH 2 TO 6 FERMIS.BALTAY   66 HBC      3.7 PBAR P      8/66
M   A  100(1016.)    (10.)             ASTIER   67 HBC  +-  0 PBAR P      . 7/67
M   A    SCATT.LENGTH ALSO FITS, SEE BELOW
M        SCATT.LENGTH +2.5 +-1. FERMI  ASTIER   67 HBC  +-  0-1.2 PBAR P    7/67
M        OR CMPLX, RE PART=-2.3 F      ......   .. ...  ..  ..... .... .    7/67
M                 IM PART=.5F OR LESS ......   .. ...  ..  ..... .... .    7/67
M   B        (1.8)     (0.4)     (0.3)  DUBOC    72 HBC     1.2 PBAR P,3PI2K 12/72*
M   B  ABSOLUTE VALUE OF SCAT.LENGTH                                     12/72*

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                     36  DELTA(970) WIDTH  (MEV)

W  PEAKS SEEN IN MISSING MASS EXPERIMENTS
W   S  262   (5.0)  OR LESS              KIENZLE   65 MMS   -  3-5 PI- P        9/66
W   S       (10.0)  OR LESS              OOSTENS   66 MMS   +  3.8 PP TO D + MM 9/66
W            60.0     16.0      10.0     ABOLINS   70 MMS   +  3.8-6.3 PP--D+MM 1/71
W   S  215   (5.9)  OR LESS  CL=.90      CHESHIRE  72 MMS    0 2.4 PI- P,N MM  12/72*
W   S   SEE NOTES ON DELTA MASS ABOVE

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  3/69
W       20  (50.0)  OR LESS              BARNES    69 HBC   -  4-5 K-P,PI-ETA   9/69
W            40.      15.                CAMPBELL  69 DBC  +- 2.7 PI+ D         1/73*
W   R   15  (60.0)   (30.0)              MILLER    69 HBC   -  4.5 K-N,ETA PI   7/69
W   R   21  (31.0)   (28.0)              BARDADIN  71 HBC  +- 8 PI+P,P DO PI  . 2/72
W   R  150  (30.)     (5.)               DEFOIX    72 HBC  +- 0.7 PBAR P,7 PI   1/73*
W   R   RESOLUTION NOT UNFOLDED
W           . . . . . . . . .
W   AVG      48.0     16.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

W  K KBAR ONLY, SEE THE TYPED NOTE ABOVE
W      143  (57.0)    13.0+SYSTEMATIC ROSENFELD 65 RVUE +-                   8/66
W   A  100  (25.) APPROX.                ASTIER    67 HBC  +- SEE NOTE A ABOVE  9/67

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                     36  DELTA(970) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      DELTA(970)   INTO ETA PI                         548+ 134
P2      DELTA(970)   INTO 3 PI
P3      DELTA(970)   INTO RHO PI                         770+ 134
P4   S  DELTA(970)   INTO K KBAR                         770+ 134
P4   S   SEE THE TYPED NOTE ABOVE                        770+ 134

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                     36  DELTA(970) BRANCHING RATIOS

R1      DELTA(970)   INTO (RHO PI)/(ETA PI)                (P3)/(P2)
R1            (0.25) OR LESS  CL=.70   AMMAR     70 HBC  +- 4.1,5.5K-,ETA PI. 5/70

R10     CHARGED DELTA OF KIENZLE 65 INTO (1 CHARGED)/(3 OR MORE CHARGED)
R10            1.3       0.9       0.7  KIENZLE   65 MMS   -  3-5 PI- P         9/66

R11     DELTA OF CHESHIRE 72 INTO (NEUTRAL)/(TWO-CHARGE)/(FOUR-CHARGE)
R11           (0.10)    (0.82)    (0.08) CHESHIRE  72 MMS   0 2.4 PI- P,N MM   12/72*

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Mesons

$\delta(970)$, H(990), $S^*(1000)$, $\phi(1019)$

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                              REFERENCES FOR DELTA

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+ (COLU)
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)
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+COLO)

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+NAGOYA)
BARDADIN 71 PR D4 2711        BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)

ATHERTON 72  SUBM. TO PL      +FRANEK,FRENCH,GHIDINI,HILPERT,+      (CERN)
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)

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H(990)

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35  H (990,JPG=A -) I=0

THE EVIDENCE OF BENSON 66 HAS DISAPPEARED AFTER
RE-ANALYSIS (CHAUDHARY 70). NO STATISTICALLY
SIGNIFICANT EVIDENCE FOR THE PRE-1968 H-ENHANCE-
MENT THEREFORE REMAINS (BARBARO-GALTIERI 69).
HOWEVER, GOLDHABER 69 REPORT A NEW (PI+PI-PI0)
ENHANCEMENT AT ABOUT THE SAME MASS, M=1000 MEV,
SEEN UNDER CONDITIONS DIFFERENT FROM THOSE OF THE
EARLIER OBSERVATIONS.  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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$S^*(1000)$

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3  S* (1000,JPG=0++) I=0

WE ONLY LIST DETERMINATIONS OF POLE POSITION.
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.
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S-wave $K\overline{K}$ Interactions in the Region 990-1200 MeV

Under this entry we list parameters of the S^* pole in the $I^G(J^P)C = 0^+(0^+)+$ wave. For discussion, see the entry "S-wave ππ interactions," near the beginning of these Meson Data Card Listings.

Note that possible evidence of D-wave ππ interactions in the S^* region is listed separately under $\eta_N(1080)$.

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                         3  REAL PART OF THE S* POLE POSITION (MEV)

M  H        970.       30.      130.    HOANG     69 OSPK    4. PI-P,KS KS N   1/73*
M  H        920.       80.       90.    HOANG     69 OSPK    5. PI-P,KS KS N   1/73*
M  H     CALCULATED FROM SCATTERING LENGTH FIT OF HOANG 69.
M  B       (965.)                       BEUSCH    70 OSPK    4,6 PI-P        . 1/73*
M  B     CALCULATED FROM SCATTERING LENGTH FIT OF BEUSCH 70.
M          (996.0)                      BASDEVANT 72 RVUE    SHEET 2           1/73*
M           997.       5.               PROTOPOPE 72 HBC     SHEET 2 7. PI+ P  1/73*
M          . . . . . . . . .
M   AVG     996.6      5.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                         3  NEGATIVE IMAG. PART OF THE S* POLE POSITION  (MEV)
                        CORRESPONDS TO HALF-WIDTH, NOT FULL WIDTH.

W  H         40.       40.       60.    HOANG     69 OSPK    4. PI-P,KS KS N   1/73*
W  H         30.       30.       70.    HOANG     69 OSPK    5. PI-P,KS KS N   1/73*
W  B        (13.)                       BEUSCH    70 OSPK    4,6 PI-P          1/73*
W           (65.0)                      BASDEVANT 72 RVUE                      1/73*
W  P         27.       8.               PROTOPOPE 72 HBC     7. PI+ P          1/73*
W  P     ANOTHER SOLUTION HAS 52 MEV AND NO EPSILON POLE.
W          . . . . . . . . .
W   AVG      27.4      7.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                              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        +LILLESTOL+MONTANET+  (CERN+CDEF+IRAD+LIVP)
BEUSCH   67 PL 25 B 357       +FISCHER,GOBBI,ASTBURY+          (ETHZ+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)
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,DREVILLON,BAUBILLIER,+  (EPOL+IPNP)
BATON    70 PL 33 B 528       +LAURENS,REIGNIER                   (SACLAY)
BEUSCH   70 PHILA.CONF.P.185  W.BEUSCH                         (ETHZ+CERN)
HYAMS    70 PHILA.CONF.P.41   +KOCH,BEUSCH,+   (CERN+MPIM+ETHZ+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.CONF.PROC. 5 +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
PROTOPOP 72  PREPRINT LBL-970 PROTOPOPESCU,ALSTON,BARBARO,FLATTE,+  (LBL)
WILLIAMS 72 PR D 6 3178       P.K.WILLIAMS                           (FSU)

FUJII    73 NC 13 A 311       Y.FUJII,M.KATO                       (TOKYO)

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$\phi(1019)$

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4  PHI (1019,JPG=1-- ) I=0

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                         4  PHI MASS (MEV)

M          1019.0      2.0              SCHLEIN   63 HBC    2.0 K- P          .
M          1018.6      0.5              MILLER D  65 HBC      0.0 PBAR P    8/66
M          1020.0      2.0              LONDON    66 HBC      2.2 K-P       6/66
M          1021.5      0.8              ABRAMS    67 HBC     4.2 K- P      11/67
M          1019.       3.               BARLOW    67 HBC      1.2 PBAR P   11/66
M          1021.0      4.0              DAHL      67 HBC      1-4 PI- P     9/66
M      165 1022.       1.5              MOSTEK    68 OSPK   1.8 GAMMA + C   6/68
M          1018.       0.5       0.35   HYAMS     70 OSPK   11. PI- P       6/70
M         (1020.)     (1.)              SABRE     70 DBC      3.0 K- N      1/71
M          1021.0      1.5              ALVENSLE  71 OSPK   GAMMA+C         1/72
M          1019.9      0.6              DIBIANCA  71 DBC    4.93 K- N       1/72
M      410(1019.9)    (0.3)             STOTTLEMY 71 HBC    2.9 K-P,Y K KBAR 11/71
M      120 1019.6      0.3              AGUILAR   72 HBC    3.9,4.6 K- P   12/72*
M      100 1019.9      0.4              AGUILAR   72 HBC    3.9,4.6 K- P   12/72*
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          . . . . . . . . .
M   AVG    1019.59     0.31    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
                      (SEE IDEOGRAM BELOW )

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                         4  PHI WIDTH (MEV)

W             3.5      1.0              MILLER D  65 HBC      0.0 PBAR P  . 8/66
W             6.0      4.0              LONDON    66 HBC     2.2 K-P        6/66
W             1.8      3.0       1.5    ABRAMS    67 HBC    4.2 K- P       11/67
W           (10.)   OR LESS             BARLOW    67 HBC     1.2 PBAR P    11/66
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             3.3      1.5       0.9    HYAMS     70 OSPK   11. PI- P       6/70
W             4.67     0.42             BALAKIN   71 OSPK    E+ E- COLL.BEAM 11/71
W             5.5      1.3       1.1    DIBIANCA  71 DBC    4.93 K- N       1/72
W   S        (4.7)    (0.7)             LEFRANCOI 71 OSPK   E+E- COLL. BEAMS  2/73*
W   S    SUPERSEDED BY JEAN-MARIE 73.
W      110   (4.5)    (3.0)     (4.0)   STOTTLEMY 71 HBC    2.9 K-P,Y K KBAR 11/71
W      120    4.6      1.0       0.8    AGUILAR   72 HBC    3.9,4.6 K- P   12/72*
W      100    4.7      1.3       1.0    AGUILAR   72 HBC    3.9,4.6 K- P   12/72*
W      131    5.0      1.3              COLLEY    72 HBC    10.K+ P,K+ P PHI 12/72*
W             3.81     0.34             JEAN-MARI 73 OSPK   E+E- COLL.BEAMS   2/73*
W          . . . . . . . . .
W   AVG       4.16     0.17    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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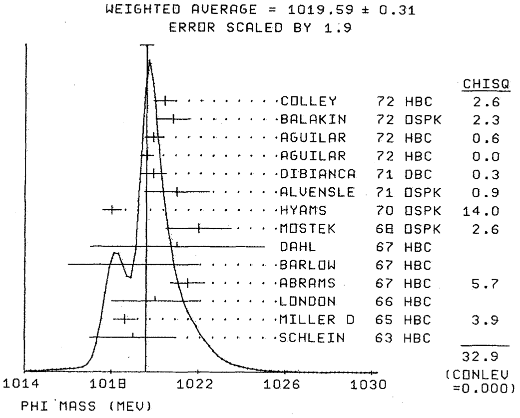
Mesons
$\phi(1019)$



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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)                783+   0
P11      PHI INTO ETA PIO (VIOLATES C)                    548+ 134
P12      PHI INTO RHO GAMMA (VIOLATES C)                  770+   0
P13      PHI INTO ETA NEUTRALS
P14      PHI INTO 5PI

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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 .4675+-.0258
 P 2   -.3525   .3496+-.0272
 P 3   -.3805     -.6557  .1524+-.0304
 P 4   -.1338     -.1588     -.1287  .0305+-.0107


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                    4  PHI BRANCHING RATIOS

R1       PHI INTO (K+ K-)/TOTAL                              (P1)
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   C        (0.493)  (0.044)       BIZOT     70 OSPK   E+ E- COLL.BEAMS 11/71
R1   C SUPERSEDED BY CHATELUS 71                                          11/71
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            . . . . . . . . . .
R1   AVG       0.507    0.022   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1   FIT       0.468    0.026  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

R2       PHI INTO (KL KS)/TOTAL                              (P2)
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            . . . . . . . . . .
R2   AVG       0.325    0.071   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.6)
R2   FIT       0.350    0.027  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

R3       PHI INTO (PI+ PI- PIO (INCL.RHO PI))/TOTAL          (P3)
R3       30    0.12     0.08         LINDSEY   66 HBC      2.7 K-P       .10/66
R3            . . . . . . . . . .
R3   FIT       0.152    0.030  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

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   FIT       0.428    0.027  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

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            . . . . . . . . . .
R6   FIT       0.187    0.044  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

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             0.69     0.14         BIZOT1    70 OSPK   E+ E- COLL.BEAM   1/71
R7            . . . . . . . . . .
R7   FIT       0.44     0.11   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

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)

R11      PHI INTO (ETA GAMMA)/TOTAL                          (P4)
R11           (0.2)  OR LESS         BADIER    65 HBC      3.0 K-P        10/66
R11           (0.08) OR LESS         LINDSEY   66 HBC      2.7 K-P        10/66
R11 A    10   (0.020)  (0.0075)      BENAKSAS  70 OSPK       E+ E-         2/72
R11 A    SUPERSEDED BY BENAKSAS2 72.
R11      27    0.073    0.019        BASILE    72 CNTR    1.8 PI- P       12/72*
R11      25    0.026    0.007        BENAKSAS2 72 OSPK   E+E- COLL.BEAMS   2/73*
R11           . . . . . . . . . .
R11 AVG        0.032    0.015   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
R11 FIT        0.030    0.011  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

R12      PHI INTO (PI+ PI- GAMMA)/(K KBAR)                   (P9)/(P1+P2)
R12           (0.05) OR LESS         LINDSEY   65 HBC      2.7 K-P        10/66

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 A     ERROR OF ASTVACATUROV 68 DOES NOT INCLUDE SIGMA(PHI) UNCERTAINTY.  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 C         (3.45)   (0.27)        BIZOT     70 OSPK   E+ E- COLL.BEAMS 11/71
R16 C SUPERSEDED BY CHATELUS 71                                          11/71
R16            2.81     0.25         BALAKIN   71 OSPK    E+ E- COLL.BEAM 11/71
R16            3.50     0.27         CHATELUS  71 OSPK   E+ E- COLL.BEAMS 11/71
R16           . . . . . . . . . .
R16 AVG        3.15     0.34    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)

R17      PHI INTO (PIO GAMMA)/(TOTAL)                        (P7)
R17           (.0035)OR LESS         BEMPORAD  69 CNTR     5.5 GAMMA N     7/69
R17 A        (0.0024)OR LESS CL=.95  BENAKSAS  70 OSPK        E+ E-        2/72
R17 A    SUPERSEDED BY BENAKSAS2 72
R17       7   (0.0025) (0.0012)      BENAKSAS2 72 OSPK   E+E- COLL. BEAMS  2/73*

R18      PHI INTO (PI+ PI-)/(TOTAL) (UNITS 10**-4)           (P8)
R18       (SEE ALSO R8)
R18         (500.)   OR LESS         LINDSEY2  65 HBC     1.7-2.7 K-P     .
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.BEAM  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           . . . . . . . . . .
R19 AVG        0.97     0.12    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R19 FIT        0.748    0.082  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

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        0.326    0.074  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

R21      PHI INTO (2PI+ 2PI- PIO)/(K+ K-)
R21           (0.02) OR LESS  CL=0.95 AGUILAR  72 HBC     3.9,4.6 K- P    12/72*

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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+ZEEM)
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
LINDSEY2 65 UCRL 16526         JAMES S. LINDSEY (THESIS)             (LRL)
MILLER D 65 CU-237(NEVIS 131)  DAVID C MILLER  (THESIS)         (COLUMBIA)

GRAY, L  66 PRL  17  501       +HAGERTY,BIZZARRI,CIAPETTI +    (SYRA+ROMA)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 24B 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)

AUGUSTIN 69 PL 28 B 517        +BIZOT,BUON,DELCOURT,HAISSINSKI,+   (ORSAY)
BALAKIN  69  IYAF 327 TRANS    +BUDKER,KORSHUNOV,MISHNEV,SIDOROV+   (NOVO)
    ALSO 69 SIDOROV
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BEMPORAD 69 PL 29 B 383          +BRACCINI,CASTALDI,LUBELSMEYER,+(PISA+BONN)
MOY      69  THESIS              KEN MIN MOY          (NORTHEASTERN UNIVERSITY)
SCOTTER  69 NC 62 A 1057         +ERSKINE,PALER,+  (BIRM+GLAS+LOIC+MPIM+OXF)
SIDOROV  69 LIVERPOOL SYMP.ON ELECTRONS+PHOTONS,P.227, SIDOROV          (NOVO)

BALAKIN  70  PREPRINT            +BUTLER,PAKHTUSOVA,SIDOROV,SKRINSKY,+(NOVO)
BENAKSAS 70  LAL 1240            +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+ (ORSA)
BIZOT    70 PL 32 416            +BUON,CHATELUS,JEANJEAN,LALANNE,+    (ORSA)
    ALSO 69 PEREZ-Y-JORBA, LIVERPOOL SYMP.69
BIZOT1   70  PRIV.COMM.          PEREZ-Y-JORBA                        (ORSA)
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)
SABRE    70  PREPRINT            SABRE COLLABOR.  (SACL+AMST+BGNA+REHO+EPOL)

ALVENSLE 71 PRL 27 441           ALVENSLEBEN,BECKER,BUSZA,CHEN,+  (MIT+DESY)
BALAKIN  71 PL 34 B 328          +BUDKER,PAKHTUSOVA,SIDOROV,SKRINSKY,+(NOVO)
DIBIANCA 71 NP B 35 13           +EINSCHLAG,ENDORF,ENGLER,FISK,+      (PITT)
CHATELUS 71  LAL 1247(THESIS) Y.CHATELUS                       (STRASBOURG)
HAYES    71 PR D 4 899           +IMLAY,JOSEPH,KEIZER,STEIN           (CORN)
LEFRANCO 71  PREPRINT LAL1256 J.LEFRANCOIS                          (ORSAY)
STOTTLEM 71  THESIS              A.R.STOTTLEMYER                 (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)
BENAKSAS272 PL 42 B 511          +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+(ORSAY)
COLLEY   72 NP B 50 1            +JOBES,RIDDIFORD,GRIFFITHS,+    (BIRM+GLAS)

JEAN-MAR 73  PRIV.COMM.          B.JEAN-MARIE,G.PARROUR              (ORSAY)
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M(1033)
→MM

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67  M(1033)

EVIDENCE NOT COMPELLING.OMITTED FROM TABLE.

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                   67  M(1033) MASS  (MEV)

M      240 1032.6      2.3              GARFINKEL 72 MMS   0 2.4 PI- P,N MM   12/72*
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                   67  M(1033) WIDTH  (MEV)

W      240   16.2      4.8       7.5    GARFINKEL 72 MMS   0 2.4 PI- P,N MM   12/72*
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                              REFERENCES FOR M(1033)

GARFINKE 72 PRL 29 1477       GARFINKEL,HOFFMAN,JACOBEL,+ (PURD+ANL+IOWA)

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$B_1(1040)$
→ωπ

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48  B1(1040)  IG=1+
EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.

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                   48  B1(1040) MASS (MEV)

M          (1040.)                      DEFOIX    72 HBC  +- 0.7 PBAR P,7 P9   2/73*
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                   48  B1(1040) WIDTH (MEV)

W            (55.)                      DEFOIX    72 HBC  +- 0.7 PBAR P,7 P9   2/73*
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                   48  B1(1040) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1     B1(1040) INTO OMEGA PI                          139+ 783
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                              REFERENCES FOR B1(1040)

DEFOIX   72  SUBMITTED TO PL  +DOBRZYNSKI,ESPIGAT,NASCIMENTO,+     (CDEF)

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$\eta_N(1080)$
→ππ

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30   ETA N (1080, JPG=N +) I=0 J GREATER THAN 1
     SOME EXPERIMENTS SUGGEST J=2.

     OMITTED FROM TABLE
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Note on $\pi^+\pi^-$ Peaks Called $\eta_N(1080)$

The $\eta_N(1080)$ is seen in $\pi^-p \rightarrow \pi^+\pi^-n$ predominantly at backward decay angles, $\cos\theta < -0.75$. OH 70 state that this "bump is almost certainly the result of P-D interference."

Note that the selection made in some HBC experiments to reduce the background under the $\eta_N(1080)$ in the reaction $\pi^-p \rightarrow \pi^+\pi^-n$ may lead to a sample of events ambiguous with $\pi^-p \rightarrow p\pi^-\pi^0\pi^0$. This is so because selection on small momentum transfer to the $\pi^+\pi^-$ system, together with large $\pi^-_{in}\pi^-_{out}$ scattering angle, leads to rather high lab momenta of the π^+, so that ionization cannot be used to discriminate between the two hypotheses (BATON 70, footnote, p. 525; and private communications from G. Laurens).

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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 1085.0     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            (1080.0)                     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)
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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)

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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+LOIC)
OH       69 PRL 23 331        +WALKER,CARROLL,FIREBAUGH,+      (WISC+TNTO)
BATON    70 PL 33 B 528       +LAURENS,REIGNIER                    (SACLAY)
CLAYTON  70 NP B 22 85        +MASON,MUIRHEAD,RIGOPOULOS,+     (LIVP+ATEN)
DIAZ     70 NP B 16 239       +GAVILLET,LABROSSE,MONTANET+     (CERN+CDEF)
OH       70 PR D 1 2494       +GARFINKEL,MORSE,WALKER,PRENTICE(WISC+TNTO)
REYNOLDS 70 NP B 21 77        +ALBRIGHT,BRADLEY,+    (OHIO+FSU+MINN+COLO)
WHITEHEA 72 NP B 48 365       WHITEHEAD,AULD,+      (AERE+RHEL+SHMP+LOUC)

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$A_1(1100)$

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10   A1(1100, JPG=1+-) I=1
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The $A_1 \rightarrow \rho\pi$ bump has been mainly observed in the diffraction-like process $\pi N \rightarrow (\pi\pi\pi)N$ without quantum number exchange and at small momentum transfer. There are also observations of structure in the A_1 mass region in reactions with production of additional mesons, and in backward production from pions (see Data Card Listings). The indications for A_1 production in charge exchange reactions, or in $\bar{p}p$ annihilation, do not appear significant.

The dominant effect in the A_1 mass region, for diffractive three-pion production, is a broad $J^P = 1^+$ $\rho\pi$ S-wave enhancement starting from $\rho\pi$ threshold; it has a maximum at ~1150 MeV and a width of the order of 300 to 400 MeV (ASCOLI 71 and 72). Such a behavior is obtained in Reggeized pion exchange models (the so-called Deck effect) [BERGER 71]. In recent partial wave analyses of the three-pion system (ASCOLI 72) one finds very little phase variation of the $J^P = 1^+$ ($\ell = 0$) $\rho\pi$ amplitude relative to various possible "background" amplitudes. Though not completely model-independent, these results suggest that the $J^P = 1^+$ $\rho\pi$ system is not resonant in the A_1 mass region. The observed effect may still be due to a pole on an unphysical sheet, shielded from the physical region by a cut due to coupling to e. g. the $S^*\pi$ channel (WRIGHT 72). In this case the Breit-Wiger approximation is not a good representation of the effects of the pole. (For further discussion of our criteria for resonances, see our text, Sect. III, 3).

For a recent review of the A_1, see DIEBOLD 72.

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                    10  A1 MASS (MEV)

M   PRODUCED BY PI +
M        (1080.0)                       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
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
M   PRODUCED BY PIONS,BACKWARDS SCATT.
M        (1115.0)   (20.0)              ANDERSON  69 MMS  -  16 PI- P,BACKW9  8/69
M        (1046.)    (10.)               BUHL      71 HBC  - 2.5 PI- P          .11/71
M
M   PRODUCED BY PBARS, SEE TYPED NOTE.
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  72 HBC +- 5.7 PBAR P          1/73*
M   A   JP ANALYSIS GIVES SOME EVIDENCE FOR RHO PI D-WAVE                       1/73*
M
M   PRODUCED BY K-, SEE TYPED NOTE.
M        (1111.)    (10.)               ALLISON   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        (1060.)    (15.)               JUHALA    67 HBC    0 4.6-5 K-P,5BODY  1/68
M
M   PRODUCED BY K+, SEE TYPED NOTE.
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 AND TYPED NOTE.
M   A
M   A       AVERAGING NOT MEANINGFUL

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                    10  A1 WIDTH (MEV)

W   PRODUCED BY PIONS, RESONANCE INTERP. CONFUSED BY DECK EFFECT
W
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     FOR JP=1+ (RHO PI) STATE                                             11/71
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
W   PRODUCED BY PIONS,BACKWARDS SCATT.
W        (98.0)    (45.0)    (20.0)     ANDERSON  69 MMS  -  16 PI- P,BACKW9  8/69
W
W   PRODUCED BY PBARS, SEE TYPED NOTE.
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  72 HBC +- 5.7 PBAR P          1/73*
W   A   JP ANALYSIS GIVES SOME EVIDENCE FOR RHO PI D-WAVE                       1/73*
W
W   PRODUCED BY K-, SEE TYPED NOTE.
W         (50.)    (50.)                ALLISON   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+, SEE TYPED NOTE.
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 AND TYPED NOTE.
W        (130.0)   (20.0)               BERLINGHI 69 HBC  + 0 12.7 K+ P         9/69
W   A
W   A       AVERAGING NOT MEANINGFUL

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                10  A1 PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      A1 INTO RHO PI                                    770+ 139
P2      A1 INTO KBAR K                                    493+ 497
P3      A1 INTO ETA PI                                    548+ 139
P4      A1 INTO ETA PRIME PI                              958+ 139
P5      A1 INTO 3 PI                                      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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                           REFERENCES FOR A1

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,O.DAHL,J.KIRZ,D.H.MILLER    (LRL)
CNOPS    68 PRL 21 1609         +HOUGH,COHN,BUGG+ (BNL+ORNL+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)
BRANDENB 70 NP B16 369          +BRENNER,IOFFREDO,JOHNSON,KIM+     (HARVARD)
CASO     70 LNC 3  707          +CORDS,COSTA+     (GENO+DESY+HAMB+MILA+SACL)
    ALSO 68 CASO
CRENNELL 70 PRL 24 781          +KARSHON,LAI,SCARR,SIMS                   (BNL)
CHIEN1   70  TORONTO PREPRINT +CHAO,JOHNSTON,PRENTICE,WALKER  (TNTO+WISC)
CHIEN2   70  JHU 7011           C.Y.CHIEN                       (JOHNS HOPKINS)
GARELICK 70 PHILAD.CONF.P.205 D.A.GARELICK,REVIEW              (NORTHEASTERN)
RABIN    70 PRL 24 925          +GALTIERI,DERENZO,FLATTE,FRIEDMAN+      (LRL)
SHIH     70  BNL 14059-REV      +YOUNG                                    (BNL)

ASCOLI   71 PRL 26 929          ILLINOIS+GENO+HAMB+MIL+SACL+HARV+TNTO+WISC
BEMPORAD 71 NP B 33 397         +BEUSCH,MELISSINOS,+  (CERN+ETHZ+LOIC+MILA)
BERGER   71 PHENOMENOLOGY  IN PARTICLE PHYSICS, CALTECH 1971           (LRL)
BUHL     71  PREPRINT           +CLINE,TERREL                     (WISCONSIN)
LAMSA    71  PREPRINT           +EZELL,GAIDOS,WILLMANN                 (PURD)  JP
RINAUDO  71 NC 5 A 239          +BOECKMANN,MAJOR+(TORI+BONN+DURH+NIJM+EPOL) JP

ANTIPOV  72 PHIL.CONF.PROC.     +ASCOLI,BUSNELLO,DAMGAARD,+      (SERP+CERN)
ATHERTON 72  SUBM. TO PL        +FRANEK,FRENCH,GHIDINI,HILPERT,+      (CERN)
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.        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)

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M(1150)
→MM

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                68  M(1150)

                EVIDENCE NOT COMPELLING.OMITTED FROM TABLE.

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                68  M(1150) MASS  (MEV)

M       65 1148.3      3.3              JACOBEL   72 MMS   0 2.4 PI- P,N MM   12/72*

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                68  M(1150)  WIDTH  (MEV)

W       65   15.0      9.0      11.7    JACOBEL   72 MMS   0 2.4 PI- P,N MM   12/72*

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                      REFERENCES FOR M(1150)

JACOBEL  72 PRL 29 671         +GARFINKEL,HOFFMAN,+           (IOWA+PURD+ANL)

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$A_{1.5}$(1170) →3π

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44  A 1.5 (1170, JPG=  -) I=1

THIS ENTRY LISTS REFERENCES TO PEAKS OF LOW STATISTI-
CAL SIGNIFICANCE IN THE 3 PI SYSTEM BETWEEN THE A1 AND
THE A2. OMITTED FROM TABLE.

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                        REFERENCES FOR A 1.5

BUTTERWO 67 HEIDELB.CONF.P.28 REVIEW TALK ON MESONS  AT HEIDELBERG CONF.
CASON    67 PRL 18  880       +LAMSA,BISWAS,DERADO,GROVES,+   (NOTREDAME)
ASCOLI   68 PRL 21 113        +CRAWLEY,KRUSE,MORTARA,SCHAFER,+ (ILLINOIS)
DONALD   68 PL 26 B  327      +FRODESEN,BETTINI,+  (LIVERPOOL,OSLO,PADUA)
VON KROG 68 PL 27B 253        +MIYASHITA,KOPELMAN,MARSHALL LIBBY   (COLO)
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)
MORSE    72 NP B 43 77        +OH,WALKER,JOHNSTON,YOON          (WISC+TNTO)

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B(1235)

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11  B (1235,JPG=1++) I=1

JP=2+ NOT YET COMPLETELY RULED OUT. FRENKIEL 72 FIT
TWO STATES ,JP=1+ AND JP=1- ,IN THE B-REGION.

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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        25(1250.)   ESTIMATED      LEE        67 HBC  -   3.6 PI- P       1/68
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    B  300(1245.)    (10.)         BIZZARRI   69 HBC  +-  0 PBAR P       12/72*
M    B   SUPERSEDED BY FRENKIEL 72
M           1240.0     20.0         ANDERSON   70 CNTR   0 5-18 GAMMA P   11/70
M    C     (1265.0)   (19.0)        CASO       70 HBC  - 11.2PI-P          2/73*
M    C   SUPERSEDED BY AFZAL 73
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    P   HANDDRAWN BACKGROUND.ERRORS STATISTICAL ONLY.                    11/71
M    W     (1228.)     (5.)         FRENKIEL   72 HBC  +- 0. PBAR PI,5 PI 12/72*
M    W   FIT REQUIRES AN ADDITIONAL JP=1- RESONANCE
M    W   AT 1256 MEV, WIDTH 129 MEV.
M   O  1163 1243.      6.           OTT        72 HBC  + 7.1 PI+ P,P B+    2/73*
M   O    FROM FIT OF THE MASS SPECTRUM
M    A     (1252.)    (6.)          OTT        72 HBC  + 7.1 PI+ P,P B+    2/73*
M    A   FROM FIT OF MASS SPECTRUM AND MOMENTS DISTRIBUTION WITH A STRONG
M    A   INTERFERENCE WITH THE BACKGROUND.
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           . . . . . . . . .
M    AVG    1236.8     5.6      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                             (SEE IDEOGRAM BELOW )
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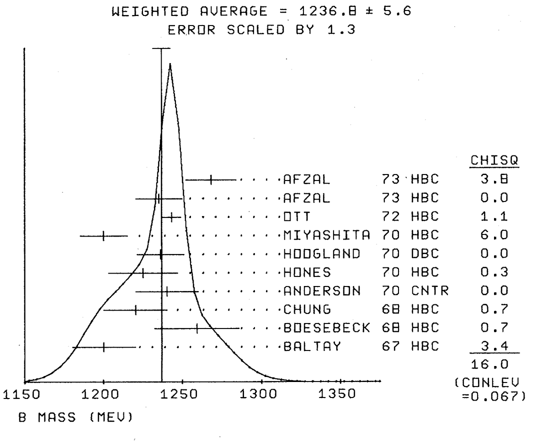

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                 11  B WIDTH (MEV)

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   B 300  (83.)     (12.)              BIZZARRI  69 HBC  +-  0 PBAR P        12/72*
W   B   SUPERSEDED BY FRENKIEL 72
W          (100.0)  APPROX.             ANDERSON  70 CNTR   0 5-18+GAMMA P    11/70
W   C      (150.0)                      CASO      70 HBC  - 11.2PI-P           2/73*
W   C   SUPERSEDED BY AFZAL 73
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   P   HANDDRAWN BACKGROUND.ERRORS STATISTICAL ONLY.                         11/71
W   W      (126.)    (10.)              FRENKIEL  72 HBC  +- 0. PBAR PI,5 PI  12/72*
W   W   SEE NOTE UNDER THE MASS ABOVE.
W  O  1163  134.      23.      26.      OTT       72 HBC  + 7.1 PI+ P,P B+     2/73*
W  O    FROM FIT OF THE MASS SPECTRUM
W   A      (156.)    (21.)     (18.)    OTT       72 HBC  + 7.1 PI+ P,P B+     2/73*
W   A   SEE NOTE UNDER THE MASS ABOVE.
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           . . . . . . . . .
W   AVG     118.3     8.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                 11  B PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      B INTO OMEGA+PI                                783+ 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

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)+- PI0) / (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

ABOLINS   63 PRL 11 381        ABOLINS,LANDER,MEHLHOP,XUONG,YAGER   (UCSD)
BONDAR    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
GOLDHABE 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+FORMAN+FERBEL            (YALE+ROCH)

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          +GUSTAVSON,JOHNSON,+   (SLAC+CIT+UCSB+NEAS)
CASO      70 LNC 3 707         +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
CASON     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)
HOOGLAND 70 PL 33 B 631        SABRE COLLABOR.  (ZEEM+SACL+BGNA+REHO+EPOL)
MIYASHIT 70 PR D 1 771         MIYASHITA,VON KROGH,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
DEVONS    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               +BASSLER,+       (DURH+GENO+DESY+MILA+SACL)  JP

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f(1270)

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                    5   F (1270,JPG=2++) I=0

                   WE NO LONGER LIST EVERY PUBLISHED VALUE.                 1/73*
                   WE AVERAGE ONLY THE MOST SIGNIFICANT                     1/73*
                   DETERMINATIONS OF MASS AND WIDTH.                        1/73*

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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    J      JOHNSON 68 INCLUDES BONDAR 63, LEE 64, DERADO 65, EISNER 67.
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    C      1277.      16.            EISENSTE   70 DBC      4.2 PI+ N          1/71
M    C      INCLUDES 14 MEV SYSTEMATIC ERROR ESTIMATED FROM RHO MASS SHIFT
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
M   E    EVIDENCE FOR A STRUCTURE CLAIMED                                     12/72*
M   T    ERROR INCREASED BY US. SEE TYPED NOTE ON K* MASS.
M           . . . . . . . . . .
M    AVG    1269.9      2.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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    J      JOHNSON 68 INCLUDES BONDAR 63, LEE 64, DERADO 65, EISNER 67.
W            131.0     25.0           ARMENISE   70 HBC      9 PI+ N -- MM P    1/71
W            173.0     11.0           ARMENISE   70 HBC      9 PI+ N -- F P     1/71
W       600  120.0     15.0           OH         70 HBC     1.26 PI- P,P F      1/71
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*
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
W   E    EVIDENCE FOR A STRUCTURE CLAIMED                                     12/72*
W   T    ERROR INCREASED BY US. SEE TYPED NOTE ON K* MASS.
W           . . . . . . . . . .
W    AVG     162.9      8.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                            (SEE IDEOGRAM BELOW )
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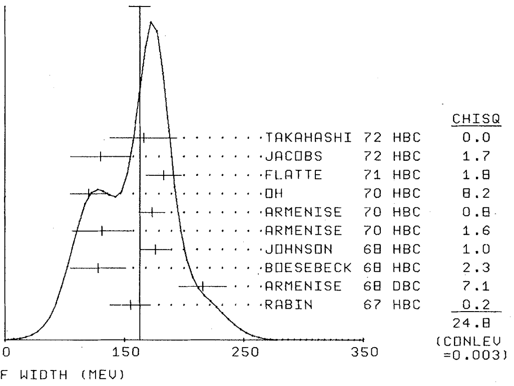
WEIGHTED AVERAGE = 162.9 ± 8.8
ERROR SCALED BY 1.7

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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 K KBAR                                   497+ 497
P4        F INTO K KBAR PI                                497+ 497+ 139
P5        F INTO ETA PI PI                                548+ 139+ 139

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                    5   F BRANCHING RATIOS

R10      F PARTIAL WAVE (I.E. I=1, JP=2+) AMPLITUDE AT F RESONANCE
R10           WE TABULATE X = 1/2 (1 + ETA).  THIS SHOULD BE PI PI FRACTION
R10           FOR PURE BW WITH NO BACKGROUND.
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
R10            . . . . . . . . .
R10 AVG         0.820    0.031    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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
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             . . . . . . . . .
R1   AVG        0.047    0.011    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2       F INTO (K KBAR)/(PI PI)                                 (P3)/(P1)
R2            DETERMINATION DIFFICULT BECAUSE PROXIMITY OF A2 WHICH HAS SAME
R2            NEUTRAL (K KBAR) MODES. SINCE INTERFERENCE MAY BE CONSTRUCTIVE
R2            OR DESTRUCTIVE, EVEN UPPER LIMITS ARE DUBIOUS.
R2       SOME UPPER LIMITS (X OR LESS) HAVE BEEN PUNCHED AS (0 +-X)
R2             (0.00)    (0.09)           BARMIN    65 HLBC       2.8 PI-          2/73*
R2             (0.00)    (0.16)           WANGLER   65 HBC        3.0 PI-P         2/73*
R2              PROBABLY SEEN             BARLOW    67 HBC       1.2 PBAR P--K1K1 11/66
R2             (0.047)   (0.012)+ SYST.   BEUSCH    67 OSPK      5,7,12 PI-P     . 9/67
R2      D       0.05      0.05            DAHL      67 HBC        1.6-4.2 PI- P   10/66
R2      D       CORRECTED BY O.DAHL                                              11/71
R2    A        (0.031)   (0.012)          ADERHOLZ  69 HBC        8 PI+ P,K+K-PI-  8/69
R2    A         K+K- PEAK IS AT ABOUT 1260 MEV WHILE (KKBAR)+ PEAKS AT 1320.
R2    A         ALSO (CROSSSECTION*BRANCHING RATIO) FOR A2 IS SMALL.
R2             (0.06)    (0.02)           OH        70 HBC       1.26 PI- P,P F    1/73*
R2 L           (0.07) OR LESS  CL=.95     AGUILAR   72 HBC       3.9,4.6 K- P     12/72*
R2 L            0.0       0.04            LIMIT ABOVE RESTATED FOR AVERAGING      12/72*
R2 L     SMALL (CROSS SECTION*BRANCHING RATIO) FOR A2                             12/72*
R2              0.13      0.05            BISWAS    72 HBC       18.5 PI+- P       1/73*
R2             (0.02) OR LESS  CL=.85     WHITEHEAD 72 ASPK      3.1-3.6 PI- P    12/72*
R2             . . . . . . . . .
R2   AVG        0.051     0.063   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)

R3       F INTO (KO K- PI+ AND C.C.)/(PI PI)                     (P4)/(P1)
R3             (0.07) OR LESS  CL=.95     AGUILAR    72 HBC       3.9,4.6 K- P    12/72*

R4       F  INTO (ETA PI PI)/(PI PI)                             (P5)/(P1)
R4             (0.19) OR LESS  CL=.95     AGUILAR    72 HBC       3.9,4.6 K- P    12/72*

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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 MOSC)
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)

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,GOBBI,ASTBURY+            (ETHZ+CERN)
DAHL     67 PR 163 1377          +HARDY+HESS+KIRZ+MILLER                  (LRL)
EISNER   67 PR 164 1699          +JOHNSON+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)
    ALSO  63BONDAR, LEE 64, DERADO 65, EISNER 67
LAMSA    68 PR 166 1395          +CASON+BISWAS+DERADO+GROVES+     (NOTREDAME)
    ALSO 67 POIRIER
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)
EISENSTE 70  COO 1195 194        EISENSTEIN,GORDON                        (ILL)
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.CONF.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)

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Data Card Listings

For notation, see key at front of Listings.

Mesons
D(1285), A_2(1310)

D(1285)

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8  D (1285,JPG=  +) I=0
(JP=0-,1+,2- WITH 1+ FAVORED.)

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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    S   SEEN IN THE MISSING MASS SPECTRUM                                 12/72*
M            . . . . . . . . .
M    AVG    1286.1    2.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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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  U     UNFOLDED BY DOBRZYNSKI 71
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   S    SEEN IN THE MISSING MASS SPECTRUM                                 12/72*
W   R  RESOLUTION NOT UNFOLDED                                             11/71
W            . . . . . . . . .
W   AVG      20.6     9.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

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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+ 770
P3      D INTO ETA PI PI                                548+ 134+ 134
P4      D INTO DELTA PI                                 970+ 134
P5      D INTO 2PI+ 2PI-                                139+ 139+ 139+ 139

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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   R   REVISED BY DEFOIX 72
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 K     K KBAR SYSTEM CHARACTERIZED BY THE I=1 THRESHOLD
R2 K     ENHANCEMENT (SEE UNDER DELTA(970)).
R2           . . . . . . . . .
R2  AVG        0.173    0.039   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      D INTO (DELTA PI)/(ETA PI PI)                   (P4)/(P3)
R3             POSSIBLY SEEN         AMMAR     70 HBC        4.1,5.5K-,ETA  5/70
R3             POSSIBLY SEEN         OTWINOWSK 70 HBC     8 PI+ P, P+6PI    9/69
R3           (0.8)    (0.2)          DEFOIX    72 HBC     0.7 PBAR P,7 PI . 1/73*

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

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                          REFERENCES FOR D

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
D.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)
DONALD   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)
DOBRZYNS 71  PRIV.COMMUN.      L.DOBRZYNSKI                     (CERN+CDEF)
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)

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A_2(1310)

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12  A2 (1310,JPG=2+-) I=1
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We list the A_2 as an ordinary Breit-Wigner resonance. This conclusion is based on the failure of experiments with high statistics and good resolution to confirm the reported splitting; moreover the reanalyses of the most significant "split-peak" experiment have reduced the significance of the dip and revealed some experimental difficulties (DAMGAARD 72, e.g., Fig. 8; KIENZLE 72, e.g., Fig. 6).

For a recent review see DIEBOLD 72.

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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
M     130(1310.0)                    FORINO    65 DBC  + 0 4.5 PI+ D        10/66
M    1425 1290.0     (5.0)           LEFEBVRES 65 MMSP  -  5.6,6.0 PI-P      1/73*
M        (1300.0)                    SEIDLITZ  65 DBC   -  3.2 PI-D          6/66
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          6/66
M    1060 1286.      (8.)            LEVRAT    66 MMS   -   6-7 PI- P        1/73*
M    4000 1307.      16.             CHIKOVANI 67 MMS   -  7 PI- P           8/67
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-GA 70 HBC  + 7.0 PI+P,3PI P      1/71
M     280 1313.0      7.0            BOCKMANN  70 HBC    05. PI+P            5/70
M   A  581(1288.0)  (10.0)           CASO      70 HBC  - 11.2PI-P,PI RHO     1/73*
M         1335.0     15.0            DIAZ      70 HBC  +- 0. PBAR P, 4 PI    5/70
M   D    (1330.0)   (15.0)           GARFINKEL 70 DBC   -  4.5 K-D,LAMBDA    1/71
M        (1274.0)   (22.0)           GORDON    70 DBC   0 4.2 PI+ D        . 1/71
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  C     (1307.)    (12.)            BUHL      71 HBC  - 2.5 PI- P          11/71
M  P      1315.       4.             ANTIPOV   72 CNTR -  40. PI- P,P 3PI   12/72*
M     160 1307.       7.             BLOODWORT 72 HBC  + 5.45 PI+ P,P 3PI   1/73*
M    1580 1306.       9.             CHALOUPKA 73 HBC  -  3.9 PI- P,P A2     2/73*
M
M   O   ONLY EXPERIMENTS GIVING ERROR LESS THAN 20 MEV KEPT FOR AVERAGING   12/72*
M   D   MAY BE DIFFERENT OBJECT, ALTHOUGH JPC=2++. COMPARE CRENNELL 69.
M  A    ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5) AND/OR A1
M  C       BACKWARD PRODUCTION                                              11/71
M  P    FROM A FIT TO JP=2+ RHO PI
M           . . . . . . . . .
M   AVG    1308.8     1.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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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      12(1315.0)                   ADERHOLZ  69 HBC  +   8 PI+ P,K+KO     8/69
MK     132 1301.0     7.0            ALSTON-GA 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
MK  N   THE NEUTRAL MODE CAN INTERFERE WITH THE F MESON
MK S    SYSTEMATIC ERROR IN MASS SCALE SUBTRACTED
MK          . . . . . . . . .
MK  AVG    1315.0     3.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                     (SEE IDEOGRAM BELOW )

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                12  A2 MASS (MEV),  ETA PI MODE

M      189 1312.0     7.0            ALSTON-GA 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      906(1326.)    (3.)            PREPOST   72 OSPK - 6.PI- P,P PI ETA  1/73*
M           . . . . . . . . .
M   AVG    1300.8     5.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                     (SEE IDEOGRAM BELOW )

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M       FOR THE MASSES OF A2L AND A2H SEE OUR APRIL 72 EDITION.
M       SEE ALSO THE TYPED NOTE ABOVE.

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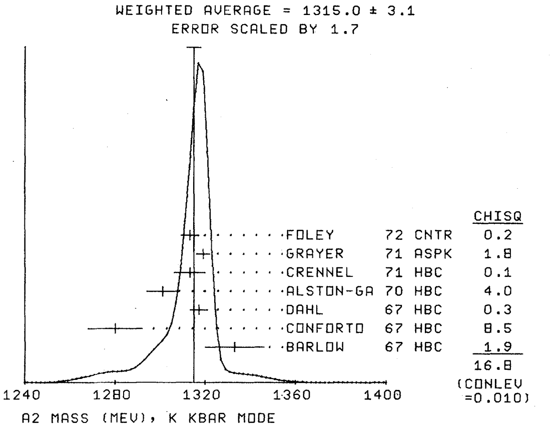
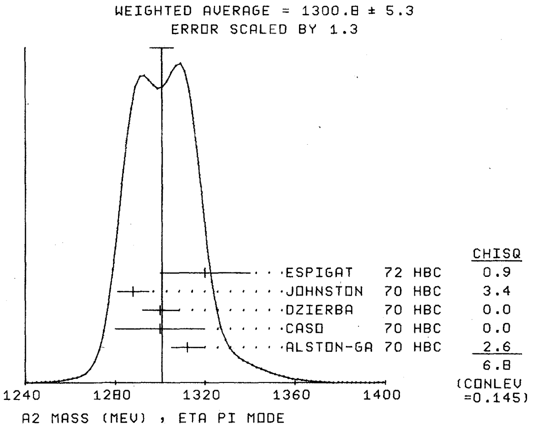
$A_2(1310)$





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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
W     1425    99.0    (15.0)                 LEFEBVRES 65 MMSP -   6.0 PI-P            1/73*
W           (140.0)                          SEIDLITZ  65 DBC  -   3.2 PI-D            6/66
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            1/67
W     1060    98.      (5.)                  LEVRAT    66 MMS  -   6,7 PI- P           1/73*
W     4000    90.      15.                   CHIKOVANI 67 MMS  -   7 PI- P             8/67
W      260    96.0     16.0                  ARMENISE  68 DBC   0 5.1 PI+D             9/67
W   O  120   (56.)    (21.)                  BOESEBECK 68 HBC   0 8 PI+ P              1/73*
W   O        (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             90.0     10.0     50.0         ANDERSON  69 MMS  -   16 PI- P,BACKW9     8/69
W   AE 241  (164.0)   (20.0)                 ARMENISE  69 DBC  +   5.1 PI+D,3PI++-     5/70
W   O        (80.0)   (30.0)                 EISENBERG 69 HBC  +  4.3,5.3 GAMMA P     12/69
W      941    79.0     12.0                  ALSTON-GA 70 HBC  +  7.0 PI+P,3PI P       1/71
W   O  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   O        (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           (215.0)   (22.0)                 GORDON    70 DBC   0 4.2 PI+ D            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  P         110.      15.                   ANTIPOV   72 CNTR -  40. PI- P,P 3PI    12/72*
W   O  160   (72.)    (25.)                  BLOODWORT 72 HBC  +  5.45 PI+ P,P 3PI 12/72*
W     1580    99.      15.                   CHALOUPKA 73 HBC  -  3.9 PI- P,P A2     2/73*
W
W   O    ONLY EXPERIMENTS GIVING ERROR LESS THAN 20 MEV KEPT FOR AVERAGING   12/72*
W   E    BACKGROUND SUBTRACTION MODEL-DEPENDENT.                              5/70
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  P     FROM A FIT TO JP=2+ RHO PI
W            . . . . . . . . .
W   AVG       99.6      2.4      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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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        80   56.0      15.0                 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        12  (34.0)                          ADERHOLZ  69 HBC  +   8 PI+ P,K+K0      8/69
WK       132   90.0      24.0                 ALSTON-GA 70 HBC  +  7.0 PI+P,K+KS P    1/71
WK       190  125.0      19.0       16.0      CRENNEL   71 HBC   - 4.5 PI- P,KSK-P   11/71
WK      1500  123.0       7.0                 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  N   THE NEUTRAL MODE CAN INTERFERE WITH THE F MESON
WK        . . . . . . . . .
WK  AVG       104.2      12.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
                             (SEE IDEOGRAM BELOW )
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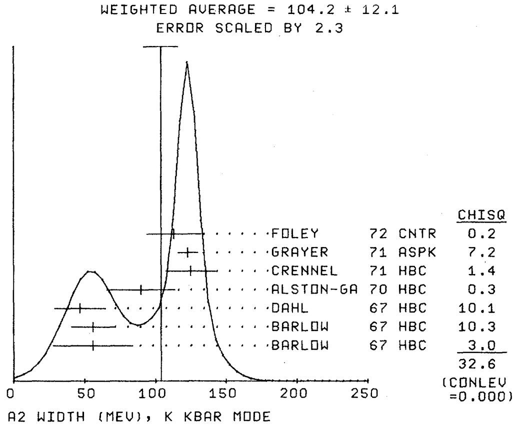

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                        12  A2 WIDTH (MEV), ETA PI MODE

W        189  103.0      20.0                 ALSTON-GA 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        906 (116.)     (16.)                 PREPOST   72 OSPK -  6.PI- P,P PI ETA  1/73*
W    T   ERROR INCREASED BY US. SEE TYPED NOTE ON K* MASS.
W          . . . . . . . . .
W    AVG     108.2      16.6      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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W        FOR THE WIDTHS OF A2L AND A2H SEE OUR APRIL 72 EDITION.
W        SEE ALSO THE TYPED NOTE ABOVE.

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                        12  A2 PARTIAL DECAY MODES

                                                              DECAY MASSES
P1       A2 INTO RHO PI                                      770+ 139
P2       A2 INTO K KBAR                                      493+ 497
P3       A2 INTO ETA PI                                      548+ 139
P4       A2 INTO OMEGA PI PI                                 139+ 139+ 783
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                                958+ 139
P   S     SMALL, NOT USED IN THE FIT

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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 1 .7236+-.0211
 P 2    .0077    .0475+-.0058
 P 3   -.2538      -.0925   .1526+-.0132
 P 4   -.7960      -.2131     -.3270   .0764+-.0223

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Data Card Listings

For notation, see key at front of Listings.

Mesons

A_2(1310), E(1420)

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                     12  A2 BRANCHING RATIOS

R1      A2 INTO (K KBAR) / (RHO PI)                         (P2)/(P1)
R1            (0.08) OR LESS           LANDER     64 HBC  +   3.5 PI+P          10/66
R1   N        (0.13)   (0.03)          BEUSCH     67 OSPK  0 5,7,12 PI<+         9/67
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   N        (0.14)   (0.05)          BOCKMANN   70 HBC   0 5.0 PI+P            9/69
R1             0.07     0.05           BOCKMANN   70 HBC  +   5.0 PI+P           9/69
R1   N  THE NEUTRAL MODE CAN INTERFERE WITH F.
R1             0.06     0.03           ABRAMOVIC  70 HBC   -  3.93 PI- P         1/71
R1   E        (0.024)  (0.006)         DIAZ       70 HBC  +- 0. PBAR P, 4 PI    11/71
R1   E SUPERSEDED BY ESPIGAT 71 (SEE UNDER R2 AND R8)                           11/71
R1             0.07     0.03           NEF        70 MMS   -  7.0 PI- P          6/70
R1     113     0.097    0.018          ALSTON-GA  71 HBC  +   7.0 PI+ P          2/71
R1      50     0.056    0.014          CHALOUPKA  73 HBC   - 3.9 PI- P,P A2      2/73*
R1           . . . . . . . . .
R1   AVG       0.0678   0.0088  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1   FIT       0.0656   0.0082 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   FIT       0.165    0.013  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            (0.072)OR LESS           DONALD     68 HBC  +-  1.2 PBAR P         6/68
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-GA  71 HBC  +   7.0 PI+ P          2/71
R3     149     0.211    0.044          CHALOUPKA  73 HBC   - 3.9 PI- P,P A2      2/73*
R3           . . . . . . . . .
R3   AVG       0.221    0.023   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3   FIT       0.211    0.021  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 S           0.02  OR LESS  CL=.97   BARNHAM    71 HBC  + 3.7 PI+ P          . 2/72
R4 S           0.0      0.01           LIMIT ABOVE RESTATED FOR AVERAGING       2/72

R5      A2 INTO (ETA PRIME PI)/(RHO PI)                     (P8)/(P1)
R5   S  14    (0.07)   (0.03)          ASCOLI     68 HBC   -  5.0 PI-P          12/72*
R5   S   SUPERSEDED BY EISENSTEIN 72
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-GA  71 HBC  +   7.0 PI+ P  .       2/71
R5            (0.011)OR LESS  CL=.90   EISENSTEI  72 HBC   - 5.PI- P,P 6PI      12/72*

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
R7           . . . . . . . . .
R7   FIT       3.22     0.50   FROM FIT

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           . . . . . . . . .
R8   AVG       0.039    0.017   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8   FIT       0.0514   0.0062 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)EISENBFRG  71 HBC     PHOTOPRODUCTION    11/71
R11 R    PION EXCHANGE MODEL USED IN THIS ESTIMATION                            11/71

R12     A2 INTO (OMEGA PI PI)/(RHO PI)                      (P4)/(P1)
R12  D         0.23     0.10           DEFOIX     72 HBC   0 0.7 PBAR P,7 PI     2/73*
R12  D   DECAYS TO B1(1040) PI, B1 INTO OMEGA PI .
R12  D   ERROR INCREASED TO ACCOUNT FOR POSSIBLE SYST. ERRORS
R12  D   OF COMPLICATED ANALYSIS.
R12            0.08     0.05           GARNJOST   72 HBC   0 7.1 PI+ P           2/73*
R12    279     0.10     0.05           CHALOUPKA  73 HBC   - 3.9 PI- P,P A2      2/73*
R12          . . . . . . . . .
R12 AVG        0.106    0.033   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R12 FIT        0.106    0.033  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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                              REFERENCES FOR A2

ADERHOLZ 64 PL 10 248          (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)

ABOLINS  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 COO-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+          (ETHZ+CERN)
CASON    67 PRL 18 880         +LAMSA,BISWAS,DERADO,GROVES,+    (NOTREDAME)
    ALSO 68 LAMSA
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.)
CONFORTO 67 NP B3 469          +MARECHAL,MONTANET+     (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,MORTARA,SHAPIRO,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            (LIVERPOOL)
EISENBER 69 PRL 23 1322        EISENBERG,HABER,BALLAM,CHADWICK+(REHO+SLAC)
    ALSO 67 BARLOW,67 CONFORTO .
VETLITSK 69 SJNP 9 596         VETLITSKY,GRIGOREYEV,GRISHIN,+        (ITEP)

ABRAMOVI 70 NP B 29 466        ABRAMOVICH,BLUMENFELD,BRUYANT,+       (CERN)  JP
ALSTON-GA70 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,CARMONY,YEN      (PURDUEJ)C
GORDON   70  COO 1195 179      THESIS,ILLINOIS                        (ILL)
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 BOSON SPECTROMETER GROUP          (CERN)
SUTHERLA 70 PHILAD.CONF.P.369 G.SUTHERLAND,INTERFERING RESONANCE(GLASGOW)

AGUILAR  71 PR D 4 2583        AGUILAR-BENITEZ,EISNER,KINSON          (BNL)
ALSTON-GA71 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
BUHL     71  PREPRINT          +CLINE,TERREL                    (WISCONSIN)
CLAYTON  71  PREPRINT          +MASON,MUIRHEAD,RIGOPOULOS,+     (LIVP+ATEN)
CRENNEL  71 PL 35 B 185        +GORDON,KWAN-WU LAI,SCARR              (BNL)
EISENBER 71  SLAC-PUB-933      EISENBERG,HABER,BALLAM,CHADWICK+(REHO+STAN)
FARBER   71 NP B 29 237        +DE PINTO,BISWAS,CASON,DEERY,KENNEY,+(NDAM)
FOLEY    71 PRL 26 413         +LOVE,OZAKI,PLATNER,LINDENBAUM,+ (BNL+CUNY)
GRAYER   71 PL 34 B 333        +HYAMS,JONES,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)
ANTIPOV  72 PHIL.CONF.PROC.    +ASCOLI,BUSNELLO,DAMGAARD,+     (SERP+CERN)
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,GOUSSU,+          (GENO+MILA+SACL)
DAMGAARD 72  UNPUBLISHED MEMO  +LECHANOINE,MARTIN               (BOHR+GEVA)
DEFOIX   72  SUBMITTED TO PL   +DOBRZYNSKI,ESPIGAT,NASCIMENTO,+      (CDEF)
DIEBOLD  72  BATAV.CONF.       R.DIEBOLD  RAPPORTEUR TALK             (ANL)
EISENBER 72 PR D 5 15          EISENBERG,BALLAM,DAGAN,+   (REHO+SLAC+TELA)
EISENSTE 72  COO-1195-247      EISENSTEIN,SCHULTZ,ASCOLI,IOFFREDO,+  (ILL)
ESPIGAT  72 NP B 36 93         +GHESQUIERE,LILLESTOL,MONTANET  (CERN+CDEF)
FOLEY    72 PR D 6 747         +LOVE,OZAKI,PLATNER,LINDENBAUM,+ (BNL+CUNY)
GARNJOST 72  PRIV.COMMUNIC.    M.ALSTON-GARNJOST                      (LBL)
GETTNER  72  PREPRINT NUB2145  M.GETTNER                             (NEAS)
KIENZLE  72  UNPUBLISHED MEMO  W.KIENZLE                             (CERN)
LASSILA  72 PRL 28 1491        LASSILA,YOUNG                         (IOWA)
MORSE    72 NP B 43 77         +OH,WALKER,JOHNSTON,YOON         (WISC+TNTO)
PREPOST  72 PHIL.CONF.PROC.    +CONFORTO,KEY,MOBLEY,+ (WISC+CHIC+TNTO+NAL)

CHALOUPK 73  SUBMITTED TO PL   CHALOUPKA,DOBRZYNSKI,FERRANDO,LOSTY,+(CERN)

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E(1420)

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 6  E (1420,JPG=A +) I=0

 BAILLON 67 FAVOR JP=0-. DAHL 67 FAVOR 1+ BUT DO NOT
 EXCLUDE 2-, 0-. LORSTAD 69 FIND 0- OR 1+.

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                 6  E MASS (MEV)

M          1425.       7.          BAILLON    67 HBC     0. PBAR P         11/66
M          1420.0     20.0         DAHL       67 HBC      1.6-4.2 PI- P    10/66
M          1423.      10.          FRENCH     67 HBC       3-4 PBAR P       6/67
M      310 1420.       7.          LORSTAD    69 HBC   0.7 PB 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          . . . . . . . . . .
M    AVG   1415.5      4.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

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E(1420), $X_0(1430)$, $X_1(1440)$, f′(1514)

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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   0.7 PB 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           . . . . . . . . .
W   AVG    59.8      6.0    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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                         6  E PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      E INTO K K*(892)                                    497+ 891
P2      E INTO K KBAR PI                                    497+ 497+ 139
P3      E INTO PI PI RHO                                    134+ 134+ 770
P4      E INTO DELTA PI                                     970+ 139
P5      E INTO ETA PI PI                                    548+ 139+ 139

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                         6  E BRANCHING RATIOS

R1      E INTO (KBAR K*(892) + C.C.)/(K KBAR PI)          (P1)/(P2)
R1             .50       .10            BAILLON   67 HBC      0.0 PBAR P       11/66

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

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*

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*

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                                 REFERENCES FOR E

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)

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$X_0(1430)$ $\to K_SK_S,\rho^0\rho^0$

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29  X (1430,JPG=   ) I=0

EVIDENCE NOT COMPELLING.OMITTED FROM TABLE.
PEAKS SEEN IN (KS KS) SPECTRA QUOTED UNDER
X(1440) (I=1) AS WELL.

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                       29  X(1430) MASS (MEV)

M   --------RHOO RHOO MODE-------
M         (1410.0)                      BETTINI   66 DBC    0  0. PBARP TO 5PR  9/66

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           . . . . . . . . .
M   AVG     1437.5       5.3    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                       29  X(1430) WIDTH (MEV)

W   --------RHOO RHOO MODE-------
W           (90.0)                      BETTINI   66 DBC    0 0. PBAR P TO 5PR  9/66

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           . . . . . . . . .
W ' AVG      46.4       17.0    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                                 REFERENCES FOR X(1430)

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,ASTBU+               (ETHZ+CERN)
DONALD   69 NP B 11 551         +EDWARDS,BURAN,BETTINI,+   (LIVP+OSLO+PADO)

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$X_1(1440)$ $\to K_SK_S$

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38  X (1440,JPG=   ) I=1

EVIDENCE NOT COMPELLING.OMITTED FROM TABLE.
PEAKS SEEN IN (KS KS) SPECTRA QUOTED UNDER
X(1430) (I=0) AS WELL.

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                       38  X(1440) MASS (MEV)

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    72 HBC   0 0.7 PBAR P,7 PI    2/73*
M           . . . . . . . . .
M   AVG     1437.5       5.3    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                       38  X(1440) WIDTH (MEV)

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    72 HBC   0 0.7 PBAR P,7 PI    2/73*
W           . . . . . . . . .
W   AVG      46.4       17.0    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                                 REFERENCES FOR X(1440)

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+             (ETHZ+CERN)
FOLEY    71 PRL 26 413          +LOVE,OZAKI,PLATNER,LINDENBAUM,+ (BNL+CUNY)
DEFOIX   72  SUBMITTED TO PL    +DOBRZYNSKI,ESPIGAT,NASCIMENTO,+      (CDEF)

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f′(1514)

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13  F PRIME (1514,JPG=2++) I=0

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                       13  F PRIME MASS (MEV)

M         14(1480.0)                    CRENNELL  66 HBC      6.0 PI- P          8/66
M   B      5(1460.)     (10.)           ABRAMS    67 HBC     4.25 K- P           5/67
M   B   BACKGROUND ESTIMATION DIFFICULT.                                         5/67
M           1515.0       7.0            AMMAR     67 HBC      5.5 K-P            9/67
M   S   70(1513.0)      (7.0)           BARNES    67 HBC      4.6, 5. K- P      12/72*
M   S   SUPERSEDED BY AGUILAR 72
M      100 1519.         7.             AGUILAR   72 HBC     3.9,4.6 K- P       12/72*
M       46 1514.         4.             COLLEY    72 HBC     10.K+ P            12/72*
M       47 1521.         7.             VIDEAU    72 HBC     4.K- P,L FPRIME    12/72*
M           . . . . . . . . .
M   AVG     1516.1       2.8    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                       13  F PRIME WIDTH (MEV)

W   B    5  (53.)      (18.)            ABRAMS    67 HBC     4.25 K- P           5/67
W   B   BACKGROUND ESTIMATION DIFFICULT.                                         5/67
W            35.0       25.0            AMMAR     67 HBC      5.5 K-P            9/67
W   S   70  (87.0)     (15.0)           BARNES    67 HBC      4.6, 5. K- P      12/72*
W   S   SUPERSEDED BY AGUILAR 72
W      100    69.       22.             AGUILAR   72 HBC     3.9,4.6 K- P       12/72*
W       46    28.       15.             COLLEY    72 HBC     10.K+ P            12/72*
W  E    47    40.       20.             VIDEAU    72 HBC     4.K- P,L FPRIME    12/72*
W  E    ERROR INCREASED BY US.SEE TYPED NOTE ON K* MASS.                        12/72*
W           . . . . . . . . .
W   AVG      39.9        9.7    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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+ 891
P4      F PRIME INTO ETA ETA                                548+ 548
P5      F PRIME INTO 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

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                       13  F PRIME BRANCHING RATIOS

R1      F PRIME INTO (PI+ PI-)/(K KBAR)                    (P1)/(P2)
R1             (0.2)  OR LESS  CL=.67   AMMAR     67 HBC      5.5 K-P           9/67
R1             (0.36) OR LESS  CL=.95   AGUILAR   72 HBC    3.9,4.6 K- P       12/72*

R3      F PRIME INTO (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)  JP
SCOTTER  69 NC 62 A 1057        +ERSKINE,PALER,+  (BIRM+GLAS+LOIC+MPIM+OXF)
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Data Card Listings

For notation, see key at front of Listings.

Mesons

f'(1514), F_1(1540), ρ'(1600), A_3(1640)

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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)

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F_1(1540) $\to KK\pi$

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47  F1 (1540,JPG=   ) I=1

JP = 2-,1+ FAVORED .
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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

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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

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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                               891+ 497

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                            REFERENCES FOR F1

ADERHOLZ 69 NP B 11 259       +BARTSCH,+          (AACH+BERL+CERN+KRAK+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)

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ρ'(1600) $\to 4\pi$

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65  RHO PRIME(1600,JPG=1-+) I=1
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The ρ', long sought by looking for its 2π decay, has been seen clearly only in the reaction

$$\gamma(\text{real or virtual}) \to \rho'^0 \to \rho^0\epsilon^0 \to 4\pi.$$

There is some evidence from ALVENSLEBEN 71 and BULOS 71 for a 2π bump far out on the ρ tail, but interpretation is difficult. EISENBERG 72 claim to establish a width of less than 2 MeV for $\rho' \to 2\pi$. This is not easily put in the format of the data cards below, so it is summarized here: Their 5 GeV/c π^+p experiment yields 5600 $\rho\Delta^{++}$ and <37 $\rho'\Delta^{++}$; i.e., production ratios are >100:1. With minor corrections, the OPE model then gives a ratio of coupling constants squared for the 2π decay of ρ' and ρ to be $g^2(\rho')/g^2(\rho) < 0.02$, which then yields the surprising $\Gamma(\rho' \to 2\pi) < 2$ MeV. If no 2π mode is found, MORTARA 72 suggests that the ρ' is just a ρϵ threshold on the tail of the ρ, but again EISENBERG 72 claim to refute this.

Mass and width values punched below are only indicative, because for such a broad peak they are extremely dependent on the parametrization chosen. For reviews, see DIEBOLD 72 and SILVESTRINI 72.

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                 65  RHO PRIME MASS (MEV)

M       (1600.)   APPROX.              BARBARI1  72 OSPK  0 E+ E- TO 4 PI     1/73*
M    400 1430.      50.                BINGHAM   72  HBC  0 9.3 GAM P,P 4PI  12/72*
M        1586.      22.                DAVIER    72 STRC  0 4.5-18. G P,P4PI 12/72*
M   S  400(1500.)  M.OF PEAK 400/40    SMADJA    72  HBC  0 9.3 GAM P,P 4PI  12/72*
M        . . . . . . . . . .
M   AVG    1560.7     57.5      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.9)
    S   LATER FITS GIVEN BY BINGHAM 72

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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          303.      64.               DAVIER    72 STRC  0 4.5-18. G P,P4PI 12/72*
W   S  400 (600)    FWHM      400/40   SMADJA    72  HBC  0 9.3 GAM P,P 4PI  12/72*
W   S   EXPTL. FULL WIDTH AT HALF MAX.  LATER FITS GIVEN BY BINGHAM 72
W        (350.)   APPROX.              CERADINI  73 OSPK  0 E+ E- TO 4 PI     1/73*
W        . . . . . . . . . .
W   AVG     403.8    157.5      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.9)

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                 65  RHO PRIME PARTIAL DECAY MODES

                                                         DECAY MASSES
P1     RHO PRIME INTO RHO PI PI                          139+ 139+ 770
P2     NEUTRAL RHO PRIME INTO ALL CHARGED 4 PI MODES     139+ 139+ 139+ 139
P3     RHO PRIME INTO RHO RHO                            770+ 770
P4     RHO PRIME INTO PI PI                              139+ 139
P5     RHO PRIME INTO K BAR K                            493+ 493
P6     RHO PRIME INTO PI OMEGA                           139+ 783

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                 65  RHO PRIME BRANCHING RATIOS

R1     RHO PRIME INTO (RHO PI+ PI-)/(4 PI, ALL CHARGED) (P1)/(P2)
R1 S      DOMINANT                     BARBARI1  72 OSPK  0 E+E- TO 4 PI      1/73*
R1 S        (.80)                      BINGHAM   72  HBC  0 9.3 GAM P,P 4PI   1/73*
R1 S      DOMINANT                     DAVIER    72 STRC  0 4.5-18. G P,P4PI  1/73*
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  0 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  E       (.01) OR LESS  2 SIGMA  EISENBERG 72   HBC  0 5 PI+P,2 OR 4 PI    1/73*
R3  E   SEE DISCUSSION IN TYPED MINI-REVIEW ABOVE.                            1/73*

R4     RHO PRIME INTO (K BAR K)/(4 PI, ALL CHARGED)       (P5)/(P2)
R4          (.04) OR LESS  2 SIGMA  BINGHAM    72  HBC  0 9.3 GAM P           1/73*

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                      REFERENCES FOR RHO PRIME

DAVIER   69 SLAC PUB 666      +DERADO, FRIES, LIU, MOZLEY, ODIAN + (SLAC) G

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
BARBARI1 72 LNC 3 689         BARBARINO,CERADINI,+    (FRAS+ROMA+PADO+UMD)IGJP
BARBARI2 72  BAT.CONF.PAP.561 BARBARINO,CERADINI,+    (FRAS+ROMA+PADO+UMD)
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
BRAMON   72 LNC 3 693         +GRECO (THEORETICAL PAPER)         (FRASCATI)
DAVIER   72  BAT.CONF.PAP.797 +DERADO,FRIES,LIU,MOZLEY,ODIAN,PARK,+(SLAC)
DIEBOLD  72  BATAV.CONF.      R.DIEBOLD  RAPPORTEUR TALK              (ANL)
EISENBE1 72 PR D 5 15         EISENBERG,BALLAM,DAGAN,+     (REHO+SLAC+TELA)
EISENBER 72  PREP. WIS 72/41-PH, PL(TO BE PUBL. 73), +KARSHON, +++ (REHO)
MORTARA  72  COO-1195-249     D.W.MORTARA                             (ILL)
SILVESTR 72  BATAV.CONF.      V.SILVESTRINI RAPPORTEUR TALK      (FRASCATI)
SMADJA   72 PHIL.CONF.PROC349 +BINGHAM,FRETTER,BALLAM,CHADWICK+(LBL+SLAC)

CERADINI 73  BAT.CONF.PAP.560(PL 1973)+CONVERSI,D'AN(FRAS+ROMA+PADO+MARY)IGJP

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A_3(1640)

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34  A3 (1640, JPG=2--) I = 1
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The A_3(1640) is seen as a bump in the diffraction-like process $\pi N \to (\pi\pi\pi)N$. The dominant effect is a 300-400 MeV wide enhancement in the $J^P = 2^-$ fπ S-wave system, starting from fπ threshold. Neither additional (narrower) structure in the 3π mass distribution, nor other decay modes, have been clearly established. There appears to be little variation of the $J^P = 2^-$ fπ phase in the A_3 mass region (ASCOLI 72). The situation thus resembles that of the A_1.

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$A_3(1640)$, $\omega(1675)$

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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
M          1630.      10.                 BALTAY    68 HBC  +  7, 8.5 PI+ P      6/68
M          1660.0     16.0                BARTSCH   68 HBC  +  8. PI+ P,3PI P    8/69
M          1610.      19.                 LAMSA     68 HBC  -  8.0 PI-P, PI-F   11/67
M      297 1673.0     40.0                ARMENISE  69 DBC  +  5.1 PI+D,3PI++-   5/70
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     5/70
M          1645.0     10.0                CRENNELL  70 HBC  -  6. PI- P,F PI     5/70
M   M     (1633.0)   (12.0)               MIYASHITA 70 HBC  -  6.7 PI-P,PI-F     1/71
M   M      BACKGROUND SUBTRACTION DIFFICULT.
M         (1672.0)                        BEKETOV   71 HBC  -  4.45 PI- P       11/71
M          1600.      50.                 PALER     71 DBC  + 13.PI+ D,D(3PI)+.11/71
M  P       1660.      10.                 ASCOLI    72 HBC  - 5.-25.PI- P,P A3 12/72*
M  P    FROM A FIT TO JP=2- F PI
M      260 1660.      25.                 CASO      72 HBC  + 11.7 PI+ P        11/71
M   F     (1658.)    (8.)                 HARRISON  72 HBC  - 13.,20. PI- P     12/72*
M   F   FIT ASSUMES AN ADDITIONAL PEAK AT 1830 MEV.                             12/72*
M   F   EVIDENCE FOR A SUBSTANTIAL DECAY INTO 3PI CLAIMED
M          . . . . . . . . .
M   AVG    1645.1      5.5    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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                    34  A3 WIDTH (MEV)

W       20 (100.)                         VETLITSKY 66 HBC  -  4.7 PI-P          6/66
W           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    8/69
W          100.       50.        30.      LAMSA     68 HBC  -  8.0 PI-P  PI-F   11/67
W   A  297 (240.0)   (50.0)               ARMENISE  69 DBC  +  5.1 PI+D,3PI++-   5/70
W   A   BACKGROUND SUBTRACTION MODEL-DEPENDENT.                                  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   M      BACKGROUND SUBTRACTION DIFFICULT.
W         (128.0)                         BEKETOV   71 HBC  -  4.45 PI- P       11/71
W          220.       80.                 PALER     71 DBC  + 13.PI+ D,D(3PI)+.11/71
W  P       270.       60.                 ASCOLI    72 HBC  - 5.-25.PI- P,P A3 12/72*
W  P    FROM A FIT TO JP=2- F PI
W   J      200. TO 400.                   CASO      72 HBC  + 11.7 PI+ P         1/72
W   J      FROM PARTIAL-WAVE ANALYSIS,FOR JP=2-(F PI)-STATE
W      260  190.      100.                CASO      72 HBC  + 11.7 PI+ P        11/71
W   F      (53.)     (20.)      (16.)     HARRISON  72 HBC  - 13.,20. PI- P     12/72*
W   F   FIT ASSUMES AN ADDITIONAL PEAK AT 1830 MEV.                             12/72*
W   F   EVIDENCE FOR A SUBSTANTIAL DECAY INTO 3PI CLAIMED
W          . . . . . . . . .
W   AVG    128.6      22.2    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

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                    34  A3 PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      A3 INTO 3 PI                                        134+ 134+ 134
P2      A3 INTO RHO PI                                      134+ 770
P3      A3 INTO ETA PI                                      134+ 548
P4      A3 INTO 5 PI
P5      A3 INTO K K*(892)                                   497+ 891
P6      A3 INTO K KBAR PI                                   497+ 497+ 134
P7      A3 INTO K KBAR                                      497+ 497
P8      A3 INTO F PI                                       1270+ 134
P9      A3 INTO OMEGA PI PI                                 783+ 134+ 134

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                    34  A3 BRANCHING RATIOS

R2      A3+- INTO (PI+- RHO0)/(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

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
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

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          5/70

R9      A3+- INTO (PI+- PI+ PI-)/(F PI)                   (P1C-P8)/(P8)
R9           0.06      0.47      0.06  CASO    69 HBC  -  11 PI- P          5/70
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                                           11/71

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                         REFERENCES FOR A3

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)
YOST     68  UMD  T.REPORT849  +YODH,EINSCHLAG,DAY,GLASSER            (UMD)

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)
CHIEN1   70  TORONTO PREPRINT  +CHAO,JOHNSTON,PRENTICE,WALKER  (TNTO+WISC)
CHIEN2   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
CLAYTON  71  PREPRINT          +MASON,MUIRHEAD,RIGOPOULOS,+    (LIVP+ATEN)
PALER    71 PRL 26 1675        +BADEWITZ,BARTON,MILLER,PALFREY,TEBES(PURD)

ALEXANDE 72 NP B 45 29         ALEXANDER,BAR-NIR,BEVARY,DAGAN,+     (TELA)
ARMENISE 72 LNC 4 201          +FORINO,CARTACCI,+         (BARI+BGNA+FIRZ)
ASCOLI   72  PREP.COO-1195233  ILL+TNTO+GENO+HAMB+MILA+SACL+HARV+ COLLAB.  JP
ASCOLI   72 PHIL.CONF.PROC.    INTERNAT.COLLABORATION              (ILL+)
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)

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$\boxed{\omega(1675) \to \rho^0\pi^0}$

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45  OMEGA (1675,JPG=  -) I=0, FORMERLY PHI(1675).
NAME CHANGED 1973.

THIS 3PI BUMP OVERLAPS IN MASS WITH THE A3, BUT
IN SOME EXPTS. ONE CAN ESTABLISH THAT THE
ENHANCEMENT IS (RHO 0 PI) INSTEAD OF (F PI),
SO THE OMEGA(1675) AND A3 HAVE DIFFERENT ISOSPIN.
MATTHEWS 71 SUGGEST JP=NORMAL, A POSSIBLE
RECURRENCE OF OMEGA(784).
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                    45  OMEGA(1675) MASS (MEV)

M          1636.0     20.0               ARMENISE  68 DBC    0 5.1 PI+D          9/68
M          1670.0     20.0               KENYON    69 DBC     8 PI+ D,3PI 2P     8/69
M         (1640.00)                      ARMENISE  70 DBC     9. PI+ D           1/71
M   G     (1616.0)   (30.0)              GORDON    70 DBC    0 4.2 PI+ D         1/71
M      100 1679.0     17.0               MATTHEWS  71 HBC    06.95 PI D,2P 3PI   1/71
M   G   NOT CERTAIN IF OMEGA(1675) OBSERVED IN THIS EXPERIMENT
M          . . . . . . . . .
M   AVG    1663.6     12.9    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

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                    45  OMEGA(1675) WIDTH (MEV)

W           112.0     60.0               ARMENISE  68 DBC    0 5.1 PI+D          9/68
W           100.0     40.0               KENYON    69 DBC     8 PI+ D,3PI 2P     8/69
W   G      (188.0)   (47.0)              GORDON    70 DBC    0 4.2 PI+ D         1/71
W      100  155.0     20.0               MATTHEWS  71 HBC    06.95 PI D,2P 3PI   1/71
W   G   NOT CERTAIN IF OMEGA(1675) OBSERVED IN THIS EXPERIMENT
W          . . . . . . . . .
W   AVG     141.4     17.1    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    45  OMEGA(1675) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      OMEGA(1675) INTO 3 PI                               134+ 134+ 134
P2      OMEGA(1675) INTO 5 PI                               134+ 134+ 134+ 134
P3      OMEGA(1675) INTO RHO PI                             770+ 134

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                    45  OMEGA(1675) BRANCHING RATIOS

R1      OMEGA(1675) INTO (5 PI)/(3 PI)                      (P2)/(P1)
R1              0.10      0.10          KENYON    69 DBC    0 8. PI + D        8/69

R2      OMEGA(1675) INTO (RHO PI)/(3 PI)                    (P3)/(P1)
R2  G         (0.75)    (0.11)          GORDON    70 DBC    0 4.2 PI+ D        1/71
R2      100   (0.70) OR MORE            MATTHEWS  71 HBC    0 6.95 PI D,2P3PI 11/71
R2  G    NOT CERTAIN IF OMEGA(1675) OBSERVED IN THIS EXPERIMENT

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                    45  OMEGA(1675)  CROSS SECTIONS

CS              FOR A COMPILATION SEE MATTHEWS 71 HBC     06.95 PI D,2P 3PI  1/71

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                      REFERENCES FOR OMEGA(1675)

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)
GORDON   70  COO 1195 179      THESIS,ILLINOIS                        (ILL)

MATTHEWS 71 PR D 3 2561        +PRENTICE,YOON,CARROLL,+         (TNTO+WISC)
MATTHEW1 71 LNC 1 361          +PRENTICE,YOON,CARROLL,+         (TNTO+WISC)

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g(1680) 15 G (1680,JPG = 3-+) I=1

This entry contains the 2π, 4π, ωπ, K$\overline{K}$ and K$\overline{K}$π peaks in the region of 1700 MeV. The spin-parity determination and the mass and width in the Meson Table come from the 2π decay mode. Analyses of 2π using OPE models suggest elasticity considerably less than 1 (BARTSCH 70, MATTHEWS 71). On the other hand, the discrepancies in masses, widths, and branching ratios indicate that there may be more than one $I^G = 1^+$ meson in this region (see BARNHAM 70, HOLMES 72). For convenience we have collected all the data here under a common entry, without implying that they are necessarily all related. For a review see BARTSCH 70.

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                     15   G MASS (MEV)

M      PI+ PI- MODE
M
M         1700.0    100.0              BELLINI   65 HLBC   0 6.1 PI-P            6/66
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         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        (1750.0)                      CASO      69 HBC    0 11. PI- P,N2PI      8/69
M         1737.0     23.0              ARMENISE  70 DBC    0 9 PI+ N             1/71
M  T      1687.      21.               STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D   2/72
M  T    FROM FIT WITH SINGLE BW
M   L    (1655.)     (4.)              STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D   2/72
M   L   FROM FIT WITH 2 BW
M   H    (1764.)    (15.)              STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D   2/72
M   H   FROM FIT WITH 2 BW
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         . . . . . . . . .
M  AVG    1681.7     12.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                            (SEE IDEOGRAM BELOW )
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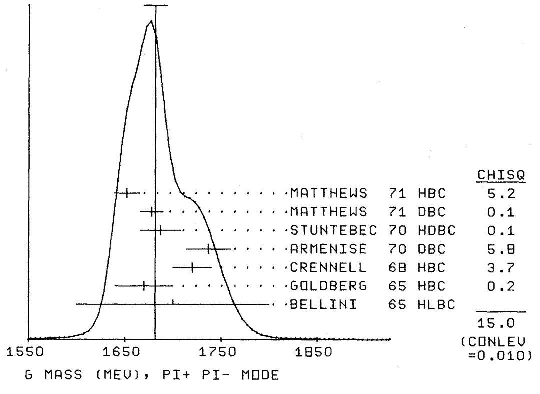
WEIGHTED AVERAGE = 1681.7 ± 12.0
ERROR SCALED BY 1.7



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M      (2PI)+- MODE
M
M         1640.0     25.0              CRENNELL  68 HBC   -  6.0 PI- P          12/68
M        (1600.)                       BARISH    69 HBC   -  8 PI- P             5/70
M     122 1650.0     35.0              BARTSCH   70 HBC   +  8 PI+ P,2 PI        5/70
M        (1652.0)   (15.0)             KRAMER    70 HBC   +  13.1 PI+ P,2PI     11/70
M         . . . . . . . . .
M  AVG    1643.4     20.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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  K   OBSERVED IN NEUTRAL(K* KBAR) MODE  (G-PARITY UNKNOWN)
M  F     (1740.)                       FRENCH    67 HBC   (KO K+-) 3-4 PBAR P   7/67
M  F     SEE FIG. 9 OF FRENCH 67
M         1640.0     20.0     25.0     CRENNELL  68 HBC   +-  6.0 PI-P,KBAR K  12/68
M      13(1650.0)                      ADERHOLZ  69 HBC   +   8 PI+ P,K+KO       8/69
M         1690.0     16.0              ADERHOLZ  69 HBC   +   8 PI+ P,KKBARPI    8/69
M         . . . . . . . . .
M  AVG    1673.2     23.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
```

```
M      (4PI)+- MODE
M
M          1720.      15.              BALTAY    68 HBC   +   7, 8.5 PI+ P       6/68
M          1710.      23.              BISWAS    68 HBC   -    8. PI- P          2/72
M  J     (1675.0)   (10.0)             JOHNSTON  68 HBC    -  7.0 PI- P          6/68
M  B     (1627.)    (12.)     (17.)    BARNHAM   70 HBC   +  10 K+ P,RHO PIPI   1/73*
M  B    INCLUDED IN HOLMES 72
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      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        (1700.)                       BALLAM    71 HBC    -  16. PI- P          2/72
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          . . . . . . . . .
M  AVG     1685.0     19.6    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)

M      (4PI)0 MODE
M
M  R     80 1717.      7.              DANYSZ    67 HBC     OSEE NOTE R BELOW   5/67
M  R     SEEN IN 2.5-3 PBAR P. 2PI+2PI-,WITH 0,1,2 PI+PI- PAIRS IN RHOO BAND
M    M    (1700.0)                     MAURER    70 HBC     05.7 PBAR P,7 PI    2/71
M    M    (1700.0)                     BRAUN     71 HBC     05.7 PBAR P,7 PI   11/71
M    M  SEEN IN 2 RHOO, NOT IN 4 PI OUTSIDE RHO BANDS,

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          . . . . . . . . .
M  AVG     1634.2     10.0    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M       R PEAKS FROM MMS. (FOR DIFFICULTIES WITH MMS EXPT SEE A2 MINIREVIEW)  1/73*
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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                     15   G WIDTH (MEV)

W      PI+ 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    0 6.0 PI- P          12/68
W          (80.0)    (20.0)            JOHNSTON  68 HBC    0 7.0 PI- P         . 6/68
W         (200.0)                      CASO      69 HBC    0 11. PI- P,N2PI      8/69
W          171.0      65.0             ARMENISE  70 DBC    0 9 PI+ D             1/71
W  T      267.        72.       46.    STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D   2/72
W  T    FROM FIT WITH SINGLE BW
W   L     (20.)       (8.)             STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D   2/72
W   L   FROM FIT WITH 2 BW
W   H     (87.)      (14.)     (20.)   STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D   2/72
W   H   FROM FIT WITH 2 BW
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         . . . . . . . . .
W  AVG     157.3      22.7    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                            (SEE IDEOGRAM BELOW )
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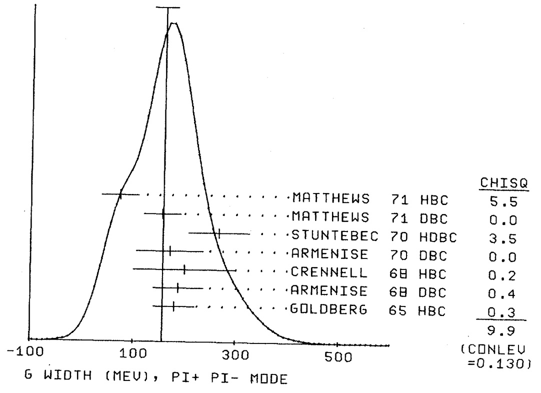
WEIGHTED AVERAGE = 157.3 ± 22.7
ERROR SCALED BY 1.3



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W      (2PI)+- MODE
W
W          200.0     100.0             CRENNELL  68 HBC   -   6.0 PI- P         12/68
W         (200.)                       BARISH    69 HBC   -   8 PI- P            5/70
W     122  180.0      30.0             BARTSCH   70 HBC   +  8 PI+ P,2 PI        5/70
W          (40.0)    (32.0)            KRAMER    70 HBC   +  13.1 PI+ P,2PI     11/70
W          . . . . . . . . .
W  AVG     181.7      28.7    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W      K KBAR + K KBAR PI MODE
W
W  F      (120.)    APPROX.            FRENCH    67 HBC  (KO K+-) 3-4 PBAR P 11/69
W  F       ABOVE VALUE ESTIMATED FROM FIG. 9 OF FRENCH 67
W           79.0      70.0      25.0   CRENNELL  68 HBC   +-  6.0 PI-P,KBAR K 12/68
W      13 (100.0)                      ADERHOLZ  69 HBC   +   8 PI+ P,K+KO       8/69
W          112.0      60.0             ADERHOLZ  69 HBC   +   8 PI+ P,KKBARPI    8/69
W          . . . . . . . . .
W  AVG      91.7      37.2    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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Mesons
g(1680), X(1690), X$^-$(1795)

Data Card Listings
For notation, see key at front of Listings.

```
W      (4PI)+- MODE
W
W            100.      35.                  BALTAY     68 HBC  +   7, 8.5 PI+ P       6/68
W            162.      58.      40.         BISWAS     68 HBC  -   8. PI- P           2/72
W    J       (90.0)    (20.0)               JOHNSTON   68 HBC   -  7.0 PI- P          6/68
W    J      NOT SEPARATED FROM 2 PI DECAY
W    B       (72.)     (29.)    (20.)       BARNHAM    70 HBC  + 10 K+ P,RHO PIPI    1/73*
W    B    INCLUDED IN HOLMES 72
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       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            . . . . . . . . .
W    AVG     128.4     17.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W      (4PI)0 MODE
W
W    R  80   (40.)     (12.)                DANYSZ     67 HBC     OSEE NOTE R BELOW. 5/67
W    R    SEEN IN 2.5-3 PBAR P. 2PI+2PI-,WITH 0,1,2 PI+PI- PAIRS IN RHOO BAND

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       R PEAKS FROM MMS. (FOR DIFFICULTIES WITH MMS EXPT SEE A2 MINIREVIEW)  1/73*
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                                         139+ 139+ 139+ 139
 P3     G INTO 2 RHO                                       770+ 770
 P4     G INTO PI PI RHO                                   139+ 139+ 770
 P5     G INTO A2 PI                                      1310+ 139
 P6     G INTO K KBAR                                      497+ 497
 P7     G INTO OMEGA PI                                    139+ 783
 P8     G INTO K KBAR PI                                   497+ 497+ 139
 P9     G INTO PHI PI                                     1019+ 139
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                        15  G BRANCHING RATIOS

R1      G INTO (2PI)/TOTAL                                (P1)
R1  P        (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  P    OPE MODEL USED IN THIS ESTIMATION

R2      G INTO (PI+- PIO) / (ALL PI+- PI+ PI- PIO)        (P1)/(P2C)
R2  D        (0.08) OR LESS              BALTAY     68 HBC  +   7-8.5 PI+ P        6/68
R2  D         USING DATA OF DEUTSCHMANN 65 ON PI+P TO PI+ PIO P                    6/68
R2            0.8        0.2             JOHNSTON   68 HBC  -   7. PI- P           2/72
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            . . . . . . . . .
R2  AVG       0.80       0.12    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      G+- INTO (2PI)/(2RHO)                             (P1)/(P3)
R3           (0.48) OR LESS              BISWAS     68 HBC  -   8. PI- P           2/72

R4      G+- INTO (K KBAR)/(2PI)                           (P6)/(P1)
R4            INDICATION SEEN            EHRLICH    66 HBC  +-0 7.9 PI- P          3/67
R4            INDICATION SEEN            ABRAMS     67 HBC    0 4.25 K- P          6/67
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            . . . . . . . . .
R4  AVG       0.080      0.026   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5      G+- INTO (K KBAR PI)/(2PI)                        (P8)/(P1)
R5            0.10       0.03            BARTSCH    70 HBC  + 8. PI+ P             2/72

R6      G+- INTO (RHO 2PI)/(ALL 4PI)                      (P4)/(P2)
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            . . . . . . . . .
R6  AVG       0.94       0.11    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R7      G+- INTO (2RHO)/(ALL 4PI)                         (P3)/(P2)
R7            SEEN                       DANYSZ     67 HBC    0 3-4 PBAR P         5/68
R7            SEEN                       BALTAY     68 HBC  +   7,8.5 PI+ P        6/68
R7           (0.63) OR MORE              BISWAS     68 HBC  -   8. PI- P           2/72
R7            SEEN                       JOHNSTON   68 HBC   -  7 PI-P             6/68
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*

R8      G+- INTO (2 RHO)/(ALL RHO 2PI)                    (P3)/(P4)
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+- A20)/(ALL 4PI)
R9                          (WITH A20 INTO (PI+ PI- PIO))
R9            0.40       0.20            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

R10     G+- INTO (PI OMEGA)/(ALL 4PI)                     (P7)/(P2)
R10                         (WITH OMEGA INTO(PI+ PI- PIO))
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           . . . . . . . . .
R10 AVG       0.184      0.050   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R11     G+- INTO (PI PHI)/(ALL 4PI)                       (P9)/(P2)
R11          (0.11) OR LESS              BALTAY     68 HBC  +   7,8.5 PI+P         6/68

R12     G+- INTO (PI+- 2PI+ 2PI- PIO)/(ALL PI+- PI+ PI- PIO)
R12          (0.15) OR LESS              BALTAY     68 HBC  +   7,8.5 PI+ P        6/68
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R13     R FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS
R13 R1        (0.37)/   (0.59)/  0.04  FOCACCI    66 MMS  -   7-12 PI-P,P MMS  2/72
R13 R2        (0.42)/   (0.56)/  0.01  FOCACCI    66 MMS  -   7-12 PI-P,P MMS  2/72
R13 R3        (0.14)/   (0.80)/  0.05  FOCACCI    66 MMS  -   7-12 PI-P,P MMS  2/72

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                               REFERENCES FOR G

BELLINI  65 NC 40 A 948        BELLINI,DI CORATO,DUIMIO,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)
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)

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X(1690)
$\to\omega\pi\pi$

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                  64  X(1690)

                  THIS ENTRY CONTAINS (OMEGA PI PI) PEAKS AROUND
                  1690 MEV. EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.

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                  64  X(1690) MASS (MEV)

M          1689.      10.             DANYSZ     67 HBC     0 3,3.6 PBAR P     1/73*
M          1670.0     18.0            YOST       68 HBC     04.3 K-P,LMBD.5PI  1/73*
M          1695.0     20.0            BARNES     69 HBC     0 4.6 K-P,OMEG2PI  1/73*
M          . . . . . . . . .
M   AVG    1686.2      8.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                  64  X(1690) WIDTH (MEV)

W            38.      18.             DANYSZ     67 HBC     0 3,3.6 PBAR P     1/73*
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*
W          . . . . . . . . .
W   AVG      56.3     14.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)

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                          REFERENCES FOR X(1690)

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)

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X$^-$(1795)

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                63  X- (1795,JPG=    ) I=1

                SEEN AS A (PBAR N) BOUND STATE IN PBAR D ANNIHILATIONS
                AT REST. NEEDS FURTHER CONFIRMATION.OMITTED FROM TABLE.
                BOGDANOVA 72 PREDICT A VECTOR MESON
                AT THIS ENERGY.

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                63  X-(1795) MASS (MEV)

M    D     1794.5      1.4          GRAY       71 DBC   -  0.PBAR D           1/72
M    D     DECAYS TO FOUR OR MORE PIONS

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                63  X-(1795) WIDTH(MEV)

W    D       (8.)    OR LESS  CL=.95   GRAY       71 DBC   -  0.PBAR D          1/72
W    D     DECAYS TO FOUR OR MORE PIONS.

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Mesons
$X^-(1795)$, $\eta/\rho(1830)$, $\omega/\pi(1830)$, $S(1930)$, $\rho(\sim 2100)$

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                         REFERENCES FOR X-(1795)

GRAY      71 PRL 26 1491         +HAGERT,KALOGEROPOULOS                 (SYRA)
BOGDANOV  72 PRL 28 1418        BOGDANOVA,DALKAROV,SHAPIRO              (ITEP)

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$\eta/\rho(1830)$ $\to 4\pi, K^*K$

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42  ETA/RHO (1830, JPG=   +)

THIS ENTRY CONTAINS 4PI AND K KBAR PI PEAKS
AROUND 1830 MEV. OMITTED FROM TABLE.

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                    42  ETA/RHO(1830) MASS (MEV)

M       110 1832.        6.               DANYSZ     67 HBC     OSEE NOTE R BELOW  5/67
M    R        SEEN IN 2.5-3. PBAR P. 2PI+2PI-, WITH 0,1,2 PI+PI- PAIRS
M    R                                                     IN RHOO BAND
M           1820.       12.               FRENCH     67 HBC     OSEE NOTE K BELOW  7/67
M    K        SEEN IN 3.-3.6 PBAR P TO (KS KO PIO...). G PARITY UNKNOWN
M            . . . . . . . . .
M    AVG    1829.6       5.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    42  ETA/RHO(1830) WIDTH (MEV)

W       110   42.       11.               DANYSZ     67 HBC     OSEE NOTE R BELOW  5/67
W    R          SEEN IN 2.5-3. PBAR P. 2PI+2PI-, WITH 0,1,2 PI+PI- PAIRS
W    R                                                     IN RHOO BAND
W             50.       23.               FRENCH     67 HBC     OSEE NOTE K BELOW  7/67
W    K          SEEN IN 3.-3.6 PBAR P TO (KS KO PIO...). G PARITY UNKNOWN
W             . . . . . . . . .
W    AVG      43.5       9.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    42  ETA/RHO(1830) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      ETA/RHO(1830) INTO 4 PI                          139+ 139+ 139+ 139
P2      ETA/RHO(1830) INTO RHO PI PI                     139+ 139+ 770
P3      ETA/RHO(1830) INTO RHO RHO                       770+ 770
P4      ETA/RHO(1830) INTO K KBAR PI                     134+ 497+ 497

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                         REFERENCES FOR ETA/RHO(1830)

DANYSZ   67 PL 24B 309         +FRENCH+KINSON+SIMAK+       (CERN+LIVERPOOL)
FRENCH   67 NC 52A 442         +KINSON+MCDONALD+RIDDIFORD+      (CERN+BIRM)
CLAYTON  72 NP B 47 81         +MASON,MUIRHEAD,RIGOPOULOS,+     (LIVP+PATR)

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$\omega/\pi(1830)$ $\to \omega\pi\pi, K^*K$

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43  OMEGA/PI (1830,JPG=  -)

THIS ENTRY CONTAINS OMEGA PI PI AND K KBAR PI PEAKS
AROUND 1830 MEV. I=1 IF (OMEGA RHO) MODE EXISTS.
THE KS KO PI PEAK, IF PRESENT AND EVEN IF NOT PART
OF ETA/RHO(1830), IS ONLY A MINOR MODE.
OMITTED FROM TABLE.

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                    43  OMEGA/PI(1830) MASS (MEV)

M    O      (1848.)     (11.)             DANYSZ     67 HBC     0 3,3.6 PBAR P     7/67
M    O       OBSERVED IN (OMEGA PI+ PI-) (AND POSSIBLY (OMEGA RHO(0))) MODE
M    K      (1820.)     (12.)             FRENCH     67 HBC     0 3,3.6 PBAR P     7/67
M    K       OBSERVED IN (KS KO PIO...) MODE  (G-PARITY UNKNOWN)

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                    43  OMEGA/PI(1830) WIDTH (MEV)

W    O        (67.)     (27.)             DANYSZ     67 HBC     0 3,3.6 PBAR P     7/67
W    O         OBSERVED IN (OMEGA PI+ PI-) (AND POSSIBLY (OMEGA RHO(0))) MODE
W    K        (50.)     (20.)             FRENCH     67 HBC     0 3-4 PBAR P       7/67
W    K         OBSERVED IN (KS KO PIO...) MODE  (G-PARITY UNKNOWN)

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                    43  OMEGA/PI(1830) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      OMEGA/PI(1830) INTO 4 PI                         139+ 139+ 139+ 139
P2      OMEGA/PI(1830) INTO OMEGA PI PI                  139+ 139+ 783
P3      OMEGA/PI(1830) INTO 2 RHO                        783+ 770
P4      OMEGA/PI(1830) INTO K KBAR PI                    139+ 497+ 497

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                         REFERENCES FOR OMEGA/PI(1830)

DANYSZ   67 NC 51A 801         DANYSZ+FRENCH+SIMAK                     (CERN)
FRENCH   67 NC 52A 442         +KINSON+MCDONALD+RIDDIFORD+        (CERN+BIRM)
CLAYTON  72 NP B 47 81         +MASON,MUIRHEAD,RIGOPOULOS,+       (LIVP+PATR)

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$S(1930)$ REGION

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31  S (1930,JPG=  )

THIS ENTRY CONTAINS THE STRUCTURE OBSERVED IN
PBAR P BACKWARD ELASTIC SCATTERING AND VARIOUS
PEAKS NEAR 1970 MEV. OMITTED FROM TABLE.
FOR REVIEW SEE DIEBOLD 72.

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                    31  S MASS (MEV)

M    N    (1929.0)   (14.0)            CHIKOVANI 66 MMSP  -  12.0 PI-P        12/72*
M    N   NOT SEEN BY BOWEN 72
M           1900.       40.            BOESEBECK 68 HBC  +   8 PI+ P,PI+ PIO  6/68
M   A       1973.0     15.0            CASO      70 HBC  - 11.2PI- P,NOTE C  5/70
M   A       SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM)  5/70
M     K     1975.0     12.0            KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
M     K     HAS IG=1+ FROM ABSENCE OF PI+PI+ PEAK. THUS JP=(ODD)-.           11/70
M    C    (1940.)      (8.)            CLINE     70 HBC   0  .25-.74 PBAR P   2/72
M    C    (1939.)                      D*ANDLAU  71 HBC   0  .37-.65 PBAR P   2/72
M    C   FROM FIT OF A SINGLE BW FORMULA TO THE PBAR P BACKWARD ELASTIC
M    C   CROSS SECTION  / COS(THETA) IN (-.9,-1.0) /.  SOME INDICATIONS
M    C   OF AN ADDITIONAL STRUCTURE IN BOTH DATA.
M    C   RESONANT INTERPRETATION QUESTIONED BY LYS 70 AND BIZZARRI 72 .
M    B    (1968.)                      BENVENUTI 71 HBC   0  .1 - .8 PBAR P   2/72
M    B   SEEN AS A BUMP IN THE PBAR P - KS KL  CROSS SECTION WITH JPC=1--.
M    B   BASED ON ONLY 71 EVENTS OF THIS REACTION.
M    B   NOT SEEN BY CARSON 72 WITH 69 EVENTS.                               12/72*
M           . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

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                    31  S WIDTH (MEV)

W    N      (35.0)  OR LESS            CHIKOVANI 66 MMSP  -  12.0 PI-P        12/72*
W    N   NOT SEEN BY BOWEN 72
W           216.     105.              BOESEBECK 68 HBC  +   8 PI+ P,PI+ PIO  6/68
W   A       (80.0)                     CASO      70 HBC  - 11.2PI- P,NOTE C  5/70
W   A      SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM)  5/70
W     K     (52.0)  OR LESS  CL=.90    KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
W     K    HAS IG=1+ FROM ABSENCE OF PI+PI+ PEAK. THUS JP=(ODD)-.            11/70
W    C      (49.)      (9.)            CLINE     70 HBC   0  .25-.74 PBAR P   2/72
W    C      (63.)                      D*ANDLAU  71 HBC   0  .37-.65 PBAR P   2/72
W    C   SEE REMARKS UNDER MASS ABOVE
W    B      (35.)                      BENVENUTI 71 HBC   0  .1 - .8 PBAR P   2/72
W    B   SEE REMARKS UNDER MASS ABOVE

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                    31  S PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      S INTO PI+ PI-                                 139+ 139
P2      S INTO PBAR P                                  938+ 938

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                         REFERENCES FOR S

CHIKOVAN 66 PL   22  233       CERN MISSING MASS SPECTROMETER GROUP (CERN)
FOCACCI  66 PRL   17  890      CERN MISSING MASS SPECTROMETER GROUP (CERN)
BOESEBEC 68 NP B 4 501         BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CLINE    68 PRL 21 1268        +ENGLISH,REEDER,TERRELL,TWITTY  (WISCONSIN)

CASO     70 LNC 3  707         +CORDS,COSTA,+   (GENO,DESY,HAMB,MILA,SACL)
CLINE    70  PREPRINT          D.CLINE,J.ENGLISH,D.D.REEDER          (WISC)J
KRAMER   70 PRL 25 396         +BARTON,GUTAY,LICHTMAN,MILLER,+     (PURDUE)
LYS      70  PREPRINT          J.LYS                                 (MICH)

BENVENUT 71 PRL 27 283         BENVENUTI,CLINE,RUTZ,REEDER,SCHERER  (WISC)
CLINE    71  REVIEW            D.CLINE,TALK AT ANL WORKSHOP JULY 71 (WISC)
D*ANDLAU 71  PREPRINT          +ASTIER,PETRI,+                  (CDEF+PISA)
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    72  PREP.NUB 2167     +EARLES,FAISSLER,GARELICK,GETTNER,+  (NEAS)
CARSON   72  BAT.CONF.PAP.498 +BUTTON-SHAFER,YAMAMOTO,+        (MASA+TOKY)
DIEBOLD  72  BATAV.CONF.       R.DIEBOLD  RAPPORTEUR TALK             (ANL)
KIENZLE  72 PHIL.CONF.PROC207 W.KIENZLE                              (CERN)
WOHLMUT  72  BAT.CONF.PAP.275 +YEE,JOHNSON,PETERS,STENGER          (HAWAII)

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$\rho(\sim 2100)$ REGION

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51  RHO (2100, JPG=  +) I=1

NICHOLSON 69 SUGGEST IG=1+,JP=3- FROM  ANALYSIS OF
DIFFERENTIAL CROSS-SECTIONS FOR PBAR PI -- 2PI.
NOT SUPPORTED BY EHRLICH 72.
OMITTED FROM TABLE.

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                    51  RHO (2100) MASS (MEV)

M          2086.0     38.0              ANDERSON  69 MMS    -  16 PI- P,BACKW   8/69
M         (2120.)                       NICHOLSON 69 CNTR   0 .7-2.4 PB P,2PI   9/69
M       50(2070.)                       TAKAHASHI 72 HBC     8. PI- P,N 2PI     1/73*

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                    51  RHO (2100) WIDTH (MEV)

W          (150.0)                      ANDERSON  69 MMS    -  16 PI- P,BACKW   8/69
W    N     (249.)                       NICHOLSON 69 CNTR   0 .7-2.4 PB P,2PI   9/69
W    N      THE WIDTH INCLUDES RESOLUTION.
W       50 (160.)                       TAKAHASHI 72 HBC     8. PI- P,N 2PI     1/73*

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                         REFERENCES FOR RHO(2100)

ANDERSON 69 PRL 22 1390        +COLLINS,BLIEDEN+                  (BNL+CARN)
NICHOLSO 69 PRL 23 603         NICHOLSON,BARISH,DELORME,+   (CIT+ROCH+BNL)

EHRLICH  72 PRL 28 1147        +ETKIN,GLODIS,HUGHES,KONDO,LU,MORI,+ (YALE)
TAKAHASH 72 PR D 6 1266        TAKAHASHI,BARISH,+     (TOHO+PENN+NDAM+ANL)

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Mesons

T(2200), ρ(~2275), U(2360)

Data Card Listings

For notation, see key at front of Listings.

T(2200) REGION

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32  T (2200,JPG=    )

THIS ENTRY CONTAINS VARIOUS PEAKS NEAR 2200 MEV.
OMITTED FROM TABLE.
FOR REVIEWS SEE BERTANZA 72, DIEBOLD 72.

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                    32  T MASS (MEV)

M        S CHANNEL NBAR N
M   B       2190.       10.           ABRAMS     70 CNTR    S CHANNEL NBAR N  1/73*
M   B    SEEN AS BUMP IN I=1 STATE. SEE ALSO COOPER 68.
M   B       BRICMAN (69) SEES NO BUMP, SPIN LESS THAN 5 IS SO EXCLUDED
M    K     (2190.0)                   KALBFLEIS 69 HBC     0 S-CHANNEL PBARP  7/69
M    K      SEEN IN PBAR P TO RHOO RHOO PIO. IG=1-.
M    K   NOT SEEN BY DONALD 72.                                              12/72*
M           2195.       5.            COHEN      72 CNTR    S CHANNEL PBAR P 12/72*
M           . . . . . . . . .
M    AVG    2194.0      4.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M        PEAKS FROM PRODUCTION EXPERIMENTS
M    N     (2195.0)    (15.0)         CHIKOVANI 66 MMSP  -  12.0 PI-P        12/72*
M    N   NOT SEEN BY BOWEN 72.
M           2207.       13.           ALLES-BOR 67 HBC     0 5.7 PBAR P      12/66
M    A      ALLES-BORELLI 67 SEE NEUTRAL MODE ONLY (PI+PI-PIO)
M           2190.0      10.0          CLAYTON    67 HBC  +- 2.5PBAR,A2+OMEGA 10/67
M           2207.0      22.0          CASO       70 HBC   - 11.2PI- P,NOTE C. 5/70
M    C      SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM)  5/70
M     D     2157.0      10.0          KRAMER     70 HBC  +  13.1 PI+ P,2PI   11/70
M     D     HAS IG=1+ FROM ABSENCE OF PI+PI+ PEAK. THUS JP=(ODD)-.           11/70
M           . . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 2.0)

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                    32  T WIDTH (MEV)

W        S CHANNEL NBAR N
W    B      (85.)                     ABRAMS     67 CNTR    S CHANNEL NBAR N  7/67
W    B       SEE NOTE B UNDER T(2200) MASS ABOVE.
W    K      BETWEEN 20 AND 80 MEV     KALBFLEIS 69 HBC     0 S-CHANNEL PBARP  7/69
W            95.        15.           COHEN      72 CNTR    S CHANNEL PBAR P 12/72*

W        PEAKS FROM PRODUCTION EXPERIMENTS
W    N      (13.0)  OR LESS           CHIKOVANI 66 MMSP  -  12.0 PI-P         8/66
W            62.        52.           ALLES-BOR 67 HBC     0 5.7 PBAR P      12/66
W           (130.0)                   CASO       70 HBC   - 11.2PI- P,NOTE C. 5/70
W    C      SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM)  5/70
W     D      68.0       22.0          KRAMER     70 HBC  +  13.1 PI+ P,2PI   11/70
W     D     HAS IG=1+ FROM ABSENCE OF PI+PI+ PEAK. THUS JP=(ODD)-.           11/70
W           . . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                    32  SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON

CS A        (5.5)                     ABRAMS     70 CNTR    S CHANNEL NBAR N  1/71
CS A     FOR I=1 NBAR N
CS            2.25      0.08          COHEN      72 CNTR    S CHANNEL PBAR P  1/73*

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                              REFERENCES FOR T

CHIKOVAN 66 PL   22  233        CERN MISSING MASS SPECTROMETER GROUP (CERN)
FOCACCI  66 PRL   17  890       CERN MISSING MASS SPECTROMETER GROUP (CERN)
   ALSO 69 CASO
ABRAMS   67 PRL 18 1209         +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)
ALLES-BO 67 NC 50 A 776         ALLES-BORELLI,FRENCH,FRISK,+    (CERN+BONN)G=-
CLAYTON  67 HEIDBG.CONF.P.57    +MASON,MUIRHEAD,FILIPPAS+(LIVERPOOL+ATHENS)
COOPER   68 PRL 20 1059         +HYMAN,MANNER,MUSGRAVE,VOYVODIC        (ANL)

BAUBILLI 69 LUND PAPER 87       BAUBILLIER,DUBOC,HURIAUX,+        (IPN+LIVP)
BRICMAN  69 PL 29 B 451         +FERRO-LUZZI,BIZARD,+        (CERN+CAEN+SACL)
CASO     69 NC 62 A 755         +CONTE,BENZ,+     (GENO+DESY+HAMB+MILA+SACL)
KALBFLEI 69 PL 29 B  259        G.KALBFLEISCH,R.STRAND,V.VANDERBURG    (BNL)
MONTANET 69 LUND CONF.P.189     L.MONTANET, RAPPORTEUR                (CERN)

ABRAMS   70 PR D 1 1917         +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)
CASO     70 LNC 3 707           +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
   ALSO 69 CASO
KALBFLEI 70 PHILAD.CONF.P.409 G.KALBFLEISCH AND D.MILLER REVUES        (BNL)
KRAMER   70 PRL 25 396          +BARTON,GUTAY,LICHTMAN,MILLER,+     (PURDUE)

BACON    71 NP B 32 66          +BUTTERWORTH,MILLER,PHELAN,+     (RHEL+LIVP)
FIELDS   71 PRL 27 1749         +COOPER,RHINES,ALLISON              (ANL+OXF)
YOH      71 PRL  26 922         +BARISH,CAROLL,LOBKOVICZ+      (CIT+BNL+ROCH)

ALEXANDE 72 NP B 45 29          ALEXANDER,BAR-NIR,BEVARY,DAGAN,+      (TELA)
BERTANZA 72  CERN 72-10         L.BERTANZA REVIEW AT CHEXBRES 72      (PISA)
BOWEN    72  PREP.NUB 2167      +EARLES,FAISSLER,GARELICK,GETTNER,+   (NEAS)
BUGG     72 PR D 6 3047         +CONDO,HART,COHN,ENDORF,+  (TENN+ORNL+CINC)
CLAYTON  72 NP B 47 81          +MASON,MUIRHEAD,RIGOPOULOS,+     (LIVP+PATR)
COHEN    72 PHIL.CONF.PROC.     K.J.COHEN                          (RUTGERS)
DIEBOLD  72  BATAV.CONF.        R.DIEBOLD  RAPPORTEUR TALK             (ANL)
DONALD   72 PL 40 B 586         +GALLETLY,EDWARDS,DE BILLY,+     (LIVP+LPNP)
DONALD   72  BAT.CONF.PAP.263 +EDWARDS,GIBBINS,BRIAND,DUBOC,+ (LIVP+LPNP)
DONALD   72  BAT.CONF.PAP.265 INTERNAT.COLLABORATION                 (LIVP+)
KIENZLE  72 PHIL.CONF.PROC207 W.KIENZLE                               (CERN)
MING MA  72 NP B 51 77          +EASTMAN,OH,PARKER,SMITH,SPRAFKA       (MSU)
WOHLMUT  72  BAT.CONF.PAP.275 +YEE,JOHNSON,PETERS,STENGER          (HAWAII)

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ρ(~2275) REGION

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52  RHO (2275, JPG=  +) I=1

NICHOLSON 69 SUGGEST IG=1+,JP=5- FROM  ANALYSIS OF
DIFFERENTIAL CROSS-SECTIONS FOR PBAR PI -- 2PI.
NOT SUPPORTED BY EHRLICH 72.
OMITTED FROM TABLE.

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                    52  RHO(2275) MASS (MEV)

M          2260.0      18.0            ANDERSON  69 MMS   -  16 PI- P,BACKW   8/69
M         (2290.)                      NICHOLSON 69 CNTR  0 .7-2.4 PB P,2PI   9/69
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                    52  RHO(2275) WIDTH (MEV)

W           (25.0)  OR LESS           ANDERSON  69 MMS   -  16 PI- P,BACKW   8/69
W   N      (165.)                     NICHOLSON 69 CNTR  0 .7-2.4 PB P,2PI   9/69
W   N       THE WIDTH INCLUDES RESOLUTION.

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                              REFERENCES FOR RHO(2275)

ANDERSON 69 PRL 22 1390         +COLLINS,BLIEDEN+                 (BNL+CARN)
NICHOLSO 69 PRL 23 603          NICHOLSON,BARISH,DELORME,+   (CIT+ROCH+BNL)
EHRLICH  72 PRL 28 1147         +ETKIN,GLODIS,HUGHES,KONDO,LU,MORI,+ (YALE)

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U(2360) REGION

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33  U (2360,JPG=    ) I=1

THIS ENTRY CONTAINS THE BROAD BUMP OBSERVED
IN THE S CHANNEL NBAR N, AND VARIOUS OTHER PEAKS,
MOSTLY CONTROVERSIAL. OMITTED FROM TABLE.
FOR REVIEW SEE ASTBURY 72, DIEBOLD 72.

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                    33  U(2360)  MASS (MEV)

M        S CHANNEL NBAR N
M   R      (2370.0)    (10.0)         RING       69 HBC    0 S-CHANNEL PBARP 11/71
M   R       NOT CONFIRMED IN EXTENSION OF THE EXP..SEE CHAPMAN 71.           11/71
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   1/73*
M   I      (2360.)      (5.)          COHEN      72 CNTR    S CHANNEL PBAR P  1/73*
M   I    ISOSPINS 0 AND 1 NOT SEPARATED

M        PEAKS FROM PRODUCTION EXPERIMENTS
M   M      (2382.0)    (24.0)         CHIKOVANI 66 MMS   -   12.0 PI-P       12/72*
M   M    NOT SEEN BY BOWEN 72                                                12/72*
M   C      (2324.0)    (20.0)         CLAYTON    67 HBC  +- 2.5PBAR,A2+OMEGA 11/69
M   C       MAY BE DIFFERENT OBJECT. VALUE QUOTED IN HEIDELBERG PROC. OF
M   C       2380 +- 10 IS MISTAKE... PRIV. COMM. FROM MUIRHEAD.
M           2370.       17.           ANDERSON   69 ASPK  - 16 PI- BKSCAT    11/69
M          (2420.0)    (25.0)         JOHNSON    70 HBC   -  12.0 PI- P       1/71
M        73(2374.)      (4.)          ATHERTON   71 HBC   0 5.7 PBAR P        2/73*

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                    33  U(2360)  WIDTH (MEV)

W        S CHANNEL NBAR N
W          (140.)                     ABRAMS     67 CNTR    S CHANNEL PBAR N  1/73*
W   R       (40.0)  OR LESS           RING       69 HBC    0 S-CHANNEL PBARP 11/71
W   R       NOT CONFIRMED IN EXTENSION OF THE EXP..SEE CHAPMAN 71.           11/71
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  11/71
W   I      (163.)      (15.)          COHEN      72 CNTR    S CHANNEL PBAR P  1/73*
W   I    ISOSPINS 0 AND 1 NOT SEPARATED

W        PEAKS FROM PRODUCTION EXPERIMENTS
W   M       (30.0)  OR LESS           CHIKOVANI 66 MMS   -   12.0 PI-P        8/66
W   M    NOT SEEN BY BOWEN 72                                                12/72*
W           (57.)                     ANDERSON   69 ASPK  - 16 PI- BKSCAT    11/69
W           (80.0)  OR LESS           JOHNSON    70 HBC   -  12.0 P+- P       1/71
W        73  (24.)  OR LESS           ATHERTON   71 HBC   0 5.7 PBAR P        2/73*

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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        (2.0)     (0.07)        COHEN      72 CNTR    S CHANNEL PBAR P  1/73*
CS   I   ISOSPINS 0 AND 1 NOT SEPARATED

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                              REFERENCES FOR U(2360)

CHIKOVAN 66 PL   22  233        CERN MISSING MASS SPECTROMETER GROUP (CERN)
FOCACCI  66 PRL   17  890       CERN MISSING MASS SPECTROMETER GROUP (CERN)

ABRAMS   67 PRL 18 1209         +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)
CLAYTON  67 HEIDBG.CONF.P.57    +MASON,MUIRHEAD,FILIPPAS+(LIVERPOOL+ATHENS)
    ALSO 71 PRIV.COMM.          W.MUIRHEAD                            (LIVP)

ANDERSON 69 PRL 22 1390         +BLESER,BIRNBAUM,EDELSTEIN,+      (BNL+CARN)
BRICMAN  69 PL 29 B 451         +FERRO-LUZZI,BIZARD,+        (CERN+CAEN+SACL)
CASO     69 LNC 3 707           +CONTE,BENZ,+     (GENO+DESY+HAMB+MILA+SACL)
RING1    69  MICH PREPRINT      +CHAPMAN,CHURCH,LYS,MURPHY,VANDERVELD(MICH)
RING     69                     JOINT PREPRINT COMBINES RING1 AND OH 70

ABRAMS   70 PR D 1 1917         +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)
JOHNSON  70  UH 511 77 70       +PETERS,STENGER,YEE                 (HAWAII)
LYS      70  PREPRINT           J.LYS                                 (MICH)
OH       70 PRL 24 1257         +PARKER,EASTMAN,SMITH,SPRAFKA,MA       (MSU)
SMITH    70  PREPRINT           G.A.SMITH                              (MSU)

ATHERTON 71  CERN PHYS.71-18    +CELNIKIER,CLAYTON,FRANEK,FRENCH,+    (CERN)
CHAPMAN  71 PR D4 1275          +GREEN,LYS,MURPHY,RING,+              (MICH)
FIELDS   71 PRL 27 1749         +COOPER,RHINES,ALLISON              (ANL+OXF)
YOH      71 PRL  26 922         +BARISH,CAROLL,LOBKOVICZ+      (CIT+BNL+ROCH)

ASTBURY  72  CERN 72-10         A.ASTBURY REVIEW AT CHEXBRES 72       (RHEL)
BOWEN    72  PREP.NUB 2167      +EARLES,FAISSLER,GARELICK,GETTNER,+   (NEAS)
COHEN    72 PHIL.CONF.PROC.     K.J.COHEN                          (RUTGERS)
DIEBOLD  72  BATAV.CONF.        R.DIEBOLD  RAPPORTEUR TALK             (ANL)
DONALD   72  BAT.CONF.PAP.265 INTERNAT.COLLABORATION                 (LIVP+)
EASTMAN  72 NP B 51 29          +MING MA,OH,PARKER,SMITH,SPRAFKA       (MSU)
KIENZLE  72 PHIL.CONF.PROC207 W.KIENZLE                               (CERN)
MING MA  72 NP B 51 77          +EASTMAN,OH,PARKER,SMITH,SPRAFKA       (MSU)
WOHLMUT  72  BAT.CONF.PAP.275 +YEE,JOHNSON,PETERS,STENGER          (HAWAII)

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Data Card Listings

For notation, see key at front of Listings.

Mesons

$N\bar{N}_{I=0}(2375)$, X(2500–3600), $K^{\pm}$, K^0, $K^*(892)$

$N\bar{N}_{I=0}(2375)$

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41   N NBAR (2375,JPG=    ) I=0

          EVIDENCE FOR RESONANCE PRELIMINARY.
          OMITTED FROM TABLE.

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                    41   N NBAR(2375) MASS

M          2375.       10.               ABRAMS     70 CNTR     S CHANNEL NBAR N  1/71
M    I   (2360.)      (5.)               COHEN      72 CNTR     S CHANNEL PBAR P  1/73*
M    I   ISOSPINS 0 AND 1 NOT SEPARATED

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                    41   N NBAR(2375) WIDTH

W         (190.)                         ABRAMS     70 CNTR     S CHANNEL NBAR N  1/71
W    I    (163.)     (15.)               COHEN      72 CNTR     S CHANNEL PBAR P  1/73*
W    I   ISOSPINS 0 AND 1 NOT SEPARATED

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                    41   N NBAR(2375) SIGMA (MB) FOR FORMATION BN

CS          (2.5)                        ABRAMS     70 CNTR                       1/71
CS   I      (2.0)     (0.07)             COHEN      72 CNTR     S CHANNEL PBAR P  1/73*
CS   I   ISOSPINS 0 AND 1 NOT SEPARATED

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                         REFERENCES FOR N NBAR (2375)

BRICMAN   69 PL 29 B 451         +FERRO-LUZZI,BIZARD,+        (CERN+CAEN+SACL)
ABRAMS    70 PR D 1 1917         +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)
COHEN     72 PHIL.CONF.PROC.     K.J.COHEN                          (RUTGERS)
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)

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X(2500–3600)

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46   X(2500-3600)

THIS ENTRY CONTAINS VARIOUS HIGH MASS NON-STRANGE
PEAKS. OMITTED FROM TABLE.
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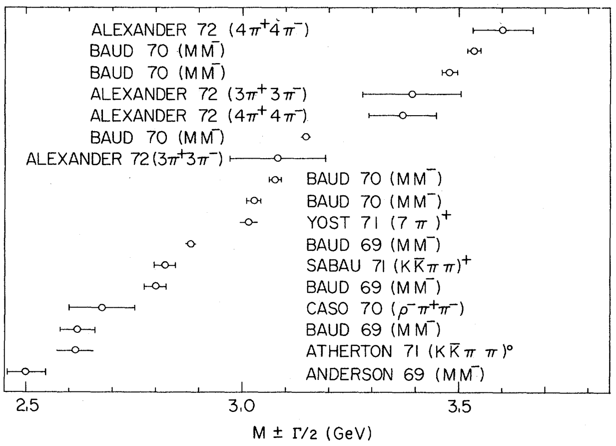
The high mass region is covered nearly continuously by evidence for peaks of various widths and decay modes (see figure). As a satisfactory grouping into particles is not yet possible, we list all the Y = 0 bumps with M > 2400 MeV together by increasing mass. Note that ANTIPOV 72 ($\pi^- p \rightarrow pMM^-$ at 25 and 40 GeV/c) see no narrow bumps.



Masses and widths of reported enhancements with Y = 0, M > 2400 MeV. (—O— indicates that upper limit only was reported for the width.)

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                46   X(2500-3600)  MASSES AND WIDTHS  (MEV)

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       66 2613.        7.            ATHERTON  71 HBC   0 5.7 PBAR P         2/73*
W       66  (90.)    OR LESS          ATHERTON  71 HBC   0 5.7 PBAR P         2/73*

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           CASO      70 HBC   - 11.2PI- P,NOTE C  5/70
W          (150.0)                    CASO      70 HBC   - 11.2PI- P,NOTE C  5/70
W    C     SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM)  5/70

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
W   C      SEEN IN (K KBAR PI PI)+ MASS DISTRIBUTION                          11/71

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(8PI)   5/71
W   Y      4.3 S.D. EFFECT   . DECAY TO 7 PIONS                               11/71

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

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   D      3080.       20.            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73*
W   D       220.       70.            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73*
    D   DECAYS TO 3PI+ 3PI-

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   D      3370.       10.            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73*
W   D       150.       40.            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73*
    D   DECAYS TO 4PI+ 4PI-

M   D      3390.       20.            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73*
W   D       220.      100.            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73*
    D   DECAYS TO 3PI+ 3PI-

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

M   D      3600.       20.            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73*
W   D       140.       20.            ALEXANDER 72 HBC   0 6.94 PBAR P        1/73*
    D   DECAYS TO 4PI+ 4PI-

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                         REFERENCES FOR X(2500-3600)

ANDERSON 69 PRL 22 1390         +COLLINS,+                         (BNL+CARN)
BAUD     69 PL  30B 129         CERN BOSON SPECTROMETER GROUP          (CERN)
ALEXANDE 70 PRL 25 63           +BAR-NIR,DAGAN,GIDAL,GRUNHAUS+    (TEL-AVIV)
BAUD     70 PL 31 B 549         CERN BOSON SPECTROMETER GROUP          (CERN)
CASO     70 LNC 3 707           +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
ATHERTON 71  CERN PHYS.71-18    +CELNIKIER,CLAYTON,FRANEK,FRENCH,+    (CERN)
SABAU    71 LNC 1 514           +URETSKY                          (BUCH+ANL)
YOST     71 PR D 3 642          +MORRIS,ALBRIGHT,BRUCKER,LANNUTTI      (FSU)
ALEXANDE 72 NP B 45 29          ALEXANDER,BAR-NIR,BEVARY,DAGAN,+      (TELA)

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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              898.0      5.0            CHADWICK  63 HBC  +   1.5 K+P
M       3870   891.0      1.0            WOJCICKI  64 HBC   -  1.7 K-P
M              889.5      2.5            ADELMAN   65 HBC   -  1.5 K-P          6/66
M              895.0      3.0            GELSEMA   65 HBC   -  1.5 K-P
M              895.       3.             BOMSE     67 HBC  +  2.3 K+P           7/67
M              891.       2.             DE BAERE  67 HBC  +  3.5 K+P (KO PI+)  7/67
M              892.5      2.5            DE BAERE  67 HBC  +  3.5 K+P (K+ PIO)  7/67
M              898.       4.             SALLSTROM 67 HBC  +  3. K+ P (KO PI+)  7/67
M              883.       5.             SALLSTROM 67 HBC  +  3. K+ P (K+ PIO)  7/67
M              890.       3.             BARLOW    67 HBC  +-  1.2 PBAR P       2/72
M              889.       3.             BARLOW    67 HBC  +-  1.2 PBAR P      11/66
M              896.0      5.0            CONFORTO  67 HBC  +-  0. PBAR P        9/67
M              893.       4.             ADERHOLZ  68 HBC   -  10 K- P          6/68
M              891.       4.             FICENEC1  68 HBC   -  1.3 K-P (K-PIO)  9/67
M              887.       3.             FICENEC1  68 HBC   -  1.3 K-P (KOPI-)  9/67
M              890.0      5.0            FICENEC2  68 HBC   -  2.7 K- P(K-PIO)  2/69
M              892.0      3.0            FICENEC2  68 HBC   -  2.7 K- P(KOPI-)  2/69
M              896.0      4.0            SCHWEINGR 68 HBC   -  4.1 K-P          9/67
M              892.0      2.0            SCHWEINGR 68 HBC   -  5.5 K-P          9/67
M              884.0      5.0            KANG      68 HBC   -  4.6 K- P         7/69
M              891.0      2.0            CRENNELL  69 DBC   -  3.9 K-N (KOPI-)  7/69
M              892.0      3.0            ERWIN     69 HBC  +   3.5 K+ P         9/69
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Mesons
$K^*(892)$

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M     2886 (894.)     (1.)              FRIEDMAN  69 HBC   -  2.1  K-P (3BDY)  2/72
M      728 (892.)     (2.)              FRIEDMAN  69 HBC   -. 2.45 K-P (3BDY)  2/72
M     3229 (892.)     (1.)              FRIEDMAN  69 HBC   -  2.6  K-P (3BDY)  2/72
M     1027 (892.)     (1.)              FRIEDMAN  69 HBC   -  2.7  K-P (3BDY)  2/72
M           895.       2.               LIND      69 HBC  +   9. K+ P          9/69
M     4404  892.2      1.5              AGUILAR1  71 HBC   -  3.9,4.6 K- P    11/71
M          . . . . . . . . .
M   AVG     891.71     0.50    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M  NEUTRAL ONLY. BUT WE DONT USE THIS FOR MASS DIFF. - SEE TYPED NOTE
M       70  897.0     10.0              COLLEY    62 HBC    0 2.0 PI-P
M      200  892.0      2.0              KRAEMER   63 HBC    0 2.3 K+P
M      150 (885.0)                      SMITH     63 HBC    0 2.3 PI-P
M           899.       4.               BARLOW    67 HBC    0 1.2 PBAR P      11/66
M           897.       4.               BARLOW    67 HBC    0 1.2 PBAR P      11/66
M           889.0      5.0              CONFORTO  67 HBC    0 0. PBAR P        9/67
M           894.7      1.3              DAUBER    67 HBC    0  2.0 K- P       12/66
M           892.0      4.0              GEORGE    67 HBC    0 5.0 K+ P        11/67
M           893.       3.               DE WIT    68 DBC    0 3. K- D          9/69
M  F        895.       4.               FICENEC1  68 HBC    0 1.3 K-P (K-PI+) 11/69
M  F        901.       4.               FICENEC2  68 HBC    0 2.7 K-P (K-PI+) 11/69
M  F FICENEC ERROR RAISED       SEE TYPED NOTE
M           896.0      4.0              SCHWEINGR 68 HBC    0 4.1 K-P          9/67
M           903.0      4.0              SCHWEINGR 68 HBC    0 5.5 K-P          9/67
M           899.0      5.0              KANG      68 HBC    0 4.6 K- P         7/69
M    10700  893.7      2.0              DAVIS     69 HBC    0 12. K+ P         9/69
M  D  2000  890.0      1.25             DE BAERE  69 HBC    0 5.0 K+ P         9/69
M  D            ERRORS ENLARGED BY US TO   GAMMA/SQRT(N). SEE TYPED NOTE.
M     4000  895.0      1.0              HABER     70 DBC    0 3. K-N           5/70
M     2934  897.9      0.8              AGUILAR1  71 HBC    0 3.9,4.6 K- P    11/71
M     5362  898.0      0.5              AGUILAR1  71 HBC    0 3.9,4.6 K- P    11/71
M  D  1700  898.4      1.3              BUCHNER   72 DBC   0 4.6 K+ N,K+ PI-P 12/72*
M          . . . . . . . . .
M   AVG     896.57     0.65    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
                      (SEE IDEOGRAM BELOW )
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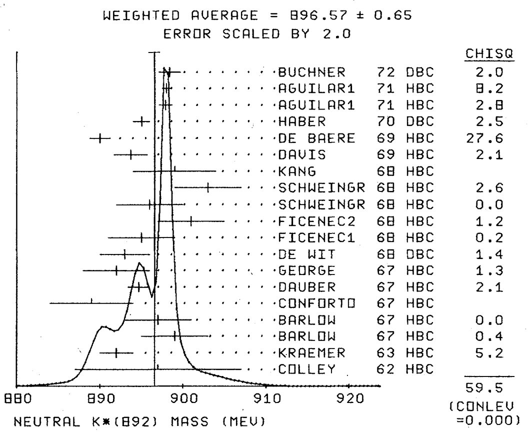

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Note on $K^*(892)$ Masses and Mass Difference

1) All mass values listed above come from physical region fits of Breit-Wigner functions. However, a recent Kπ phase shift analysis (BINGHAM 72) indicates that part of the $K^*(892)$ peak may be due to a large S wave (see note "S-wave Kπ interactions"). Because the S-wave phase shift is ambiguous ("up" and "down") in the $K^*(892)$ region, BINGHAM 72 find two solutions for the P wave:

"up" solution $m \approx 900$ MeV, $\Gamma \approx 48$ MeV

"down" solution $m \approx 895$ MeV, $\Gamma > 48$ MeV.

2) Impossibly 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:

$$\delta_{\min}(m) = \frac{\Gamma}{\sqrt{N}}, \quad \delta_{\min}(\Gamma) = 4\frac{\Gamma}{\sqrt{N}} \quad .$$

(For detailed discussion see the April 1971 edition of this note.) We have increased some unrealistic errors and scaled up some errors that are inconsistent.

3) There are two more difficulties in measuring a mass difference $m(K^{*0}) - m(K^{*\pm})$ of ~ 7 MeV when the half-width $\Gamma/2$ of the K^* is 25 MeV:

a) The two charges of K^* have different topologies; this introduces differences in the measuring and fitting of the events, which can also produce mass shifts.

b) Interferences between the resonant amplitude and background can in general shift the peak in the mass spectrum by some fraction of $\Gamma/2$.

Some reactions (symmetric under reflection of I_z) are immune to this difficulty. Thus compare the mass of K^{*0} produced in

$$\pi^- p \rightarrow \Lambda \pi^- K^+$$

with the mass of K^{*+} in the I_z-reflected reaction

$$\pi^+ n \rightarrow \Lambda \pi^+ K^0 .$$

The final-state amplitudes of each will contain not only the $|K^*\rangle$ with I-spin 1/2, but also an interfering I = 3/2 P-wave, which we can call $|K^*_{3/2}\rangle$. But I_z symmetry forces $\langle \pi^- p\, |\Lambda K^{*0}\rangle$ to equal $\langle \pi^+ n\, |\Lambda K^{*+}\rangle$; and similarly for the two $K^*_{3/2}$ amplitudes, so that the shifting of the K^* peak is the same in both reactions. Nobody has published a mass difference exploiting this fact.

```
                    18  K*(0) - K*(+-) MASS DIFF. (MEV)

D       330     6.3        6.0              BARASH    67 HBC      0 PBAR P          8/67
D      1400     6.5        5.0              FICENEC1  68 HBC        1.3 K- P        2/69
D      1600     9.5        5.0              FICENEC2  68 HBC        2.7 K- P        2/69
D      7338     5.7        1.7              AGUILAR1  71 HBC  , -0 3.9,4.6 K- P    11/71
D           . . . . . . . . .
D    AVG        6.1        1.5      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    18  K*(892) WIDTH (MEV)

W  CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE
W             46.0      8.0             CHADWICK  63 HBC  +   1.5 K+P.
W     3870    46.0      3.0             WOJCICKI  64 HBC   -  1.7 K-P
W             51.0      3.0             ADELMAN   65 HBC   -  1.5 K-P                6/66
W             47.0      4.0             FERRO-LUZ 65 HBC  +   3.0 K+P
W             50.0     15.0             GELSEMA   65 HBC   -  1.5 K-P
W             50.       5.              BOMSE     67 HBC  +  2.3 K+P                 7/67
W             53.       8.              DE BAERE  67 HBC  +  3.5 K+P (K+ PIO)        7/67
W             68.      10.              SALLSTROM 67 HBC  +  3. K+ P (KO PI+)        7/67
W             47.      10.              SALLSTROM 67 HBC  +  3. K+ P (K+ PIO)        7/67
W             44.       7.              BARLOW    67 HBC  +-  1.2 PBAR P            11/66
W             43.       9.              BARLOW    67 HBC  +- 1.2 PBAR P             11/66
W             53.       7.              BARLOW    67 HBC  +-  1.2 PBAR P            11/66
W             58.       7.              ADERHOLZ  68 HBC   -  10 K- P                6/68
W             58.      16.              FICENEC1  68 HBC   -  1.3 K-P (K-PIO)        9/67
W             44.      13.              FICENEC1  68 HBC   -  1.3 K-P (KOPI-)        9/67
W             41.0      8.0             SCHWEINGR 68 HBC   -  4.1 K-P                9/67
W             47.0      4.0             SCHWEINGR 68 HBC   -  5.5 K-P                9/67
W             57.0     13.0             FICENEC2  68 HBC   -  2.7 K- P(K-PIO)        2/69
W             48.0      9.0             FICENEC2  68 HBC   -  2.7 K- P(KOPI-)        2/69
W             52.0      8.0             KANG      68 HBC   -  4.6 K- P               7/69
W            (27.0)    (8.0)     (6.0)  ERWIN     69 HBC  +   3.5 K+ P             . 9/69
W            (53.)     (3.)             FRIEDMAN  69 HBC   -  2.1  K-P (3BDY)        2/72
W            (49.)     (4.)             FRIEDMAN  69 HBC   -  2.45 K-P (3BDY)        2/72
W            (46.)     (2.)             FRIEDMAN  69 HBC   -  2.6  K-P (3BDY)        2/72
W            (49.)     (3.)             FRIEDMAN  69 HBC   -  2.7  K-P (3BDY)        2/72
W             50.       7.              LIND      69 HBC  +   9. K+ P                5/70
W     4404    54.3      2.6       2.3   AGUILAR1  71 HBC   -  3.9,4.6 K- P          11/71
W           . . . . . . . . .
W    AVG      50.1      1.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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W  NEUTRAL ONLY.
W      70   60.0      10.0           COLLEY    62 HBC    0 2.0 PI-P
W     200   50.0       5.0           KRAEMER   63 HBC    0 2.3 K+P
W           53.       13.            BARLOW    67 HBC    0 1.2 PBAR P      11/66
W           34.        8.            BARLOW    67 HBC    0 1.2 PBAR P      11/66
W           44.        4.            DAUBER    67 HBC    0  2.0 K- P       12/66
W           58.        8.            DE WIT    68 DBC    0 3. K- D          9/69
W           52.       12.            FICENEC1  68 HBC    0 1.3 K-P (K-PI+)  9/67
W           50.0       8.0           FICENEC2  68 HBC    0 2.7 K- P(K-PI+)  2/69
W           48.0       8.0           KANG      68 HBC    0 4.6 K- P         7/69
W           51.0      11.0           SCHWEINGR 68 HBC    0 5.5 K-P          9/67
W           53.0      11.0           SCHWEINGR 68 HBC    0 4.1 K-P          9/67
W   10700   53.2       1.6           DAVIS     69 HBC    0 12. K+ P         9/69
W  D  2000  58.0       5.0           DE BAERE  69 HBC    0 5.0 K+ P         9/69
W  D          ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE.
W    4000   54.0       3.0           HABER     70 DBC    0 3. K-N           5/70
W    2934   55.8       4.2      3.4  AGUILAR1  71 HBC    0 3.9,4.6 K- P    11/71
W    5362   48.5       2.2           AGUILAR1  71 HBC    0 3.9,4.6 K- P    11/71
W  D  1700  51.4       5.0           BUCHNER   72 DBC   0 4.6 K+ N,K+ PI-P 12/72*
W
W           . . . . . . . . .
W   AVG     51.7       1.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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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

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,COH  1/73*

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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)
KRAEMER  63 ATHENS CONF 130    R KRAEMER L MADANSKY +       (JOHNS HOPKINS)
SMITH    63 PRL 10 138         SMITH,SCHWARTZ,MILLER,KALBFLEISCH,HUF+(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)

ADERHOLZ 68 NP B 5  567        +DEUTSCHMANN+  (AACH+BERL+CERN+LOIC+VIENNA)
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)
ERWIN    69 NP B 9 364         +WALKER,GOSHAW,WEINBERG    (WISC+PRIN+VAND)
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)
DE BAERE 70  CERN PHYS 70 41   +DEBAISIEUX,DE WOLF,DUFOUR,+    (BELG+CERN)
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+ETHZ+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)
CHARRIER 72 NP B 51 317        CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)
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+ZEEM)

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19  K PI S WAVE, CALLED KAPPA(750-1700 MEV)
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S-wave Kπ Interactions in the Region 750-1700 MeV

Kπ interactions in the $I(J^P) = 1/2(0^+)$ wave can be described by the elastic phase shift δ_0^1 from the Kπ threshold (~ 630 MeV) up to at least 1100 MeV (BINGHAM 72). The first inelastic S-wave thresholds are Kπππ and Kη, neither of which is known to be important below 1400 MeV. Apart from the inelastic thresholds, the S-wave ππ and Kπ interactions are reminiscent of each other. Thus, the remarks in the ππ section about the meaningfulness of resonance parameters apply.

There are two intrinsic ambiguities in the solutions plotted below:

1) Any phase shift can be shifted modulo 180°.
2) If one amplitude is dominant [e. g., the P wave near $K^*(892)$ or the D wave near $K^*(1420)$], then the observed S-P or S-D interference can be explained by two ambiguous S-wave solutions, known as "up" and "down". Readers unfamiliar with the origin of the ambiguity can find a graphical explanation in our 1972 edition.

The combination of these two sorts of ambiguities leads to the multiple paths plotted in the figure. Simplicity favors the most slowly varying ("down") solutions, but where the authors give both, we plot both.

The figure displays the δ_0^1 solutions of four experimental groups:

1) BINGHAM 72 (an international K^+ collaboration), using data on $K^+p \rightarrow K\pi\Delta^{++}$ up to 12.7 GeV/c, find two solutions for δ_0^1, neither of which is a priori preferred:
   - "up", a resonant κ with m ~890 MeV, $\Gamma \leq 30$ MeV (this requires δ_1^1 to be resonant near 900 MeV with ~ 48 MeV width). Note, however, the evidence of CHUNG 72 against a narrow-width S-wave state in the $K^*(892)$ region; in addition, the more recent partial-wave analysis of MATISON 72 (see 5, below) seems to rule out the "up" solution.
   - "down", a slowly rising δ_0^1 reaching ~ 70° at about 1100 MeV (requiring δ_1^1 to be resonant at about 895 MeV). Note that the up-down ambiguity is limited to the region 850-920 MeV. Above

920 MeV the "up" solution joins the "down" solution, since all phase shift values are determined only modulo 180°.

2) MERCER 71, using the first half of the data of BINGHAM 72, give phase shifts up to 1230 MeV, ignoring possible inelasticity.

3) YUTA 71, using 5.5 GeV/c $K^-p \rightarrow K\pi N$, agree with the solutions of BINGHAM 72, their "down" solution agreeing also with MERCER 71, ignoring possible inelasticity up to 1250 MeV.

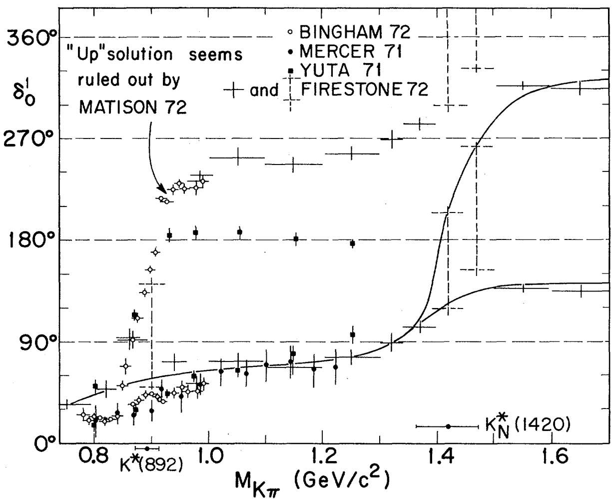
4) FIRESTONE 71 and 72, using 12 GeV/c $K^+n \rightarrow K^+\pi^-p$, have continued $K\pi$ partial wave analysis up to 1700 MeV. They find that δ_0^1 crosses 90° just below the $K^*(1420, 2^+)$, and, indeed, near 1420 MeV, shows the "up-down" ambiguity mentioned above. Their unique solutions are plotted as solid crosses, their ambiguous ones as pairs of dashed crosses joined by dashed vertical lines.

5) MATISON 72 has performed a recent analysis of 12 GeV/c $K^+p \rightarrow K^+\pi^-\Delta^{++}$ (the same reaction as studied by the International K^+ Collaboration, and with comparable statistics, but all at 12 GeV/c). Matison's analysis was similar to that of the Collaboration, except that she added two important constraints to impose internal consistency:

i) The P wave in the K^* region was determined by a Breit-Wigner fit to the Y_2^0 moment. (This yielded $m_{K^*} = 896$ MeV, $\Gamma_{K^*} = 47$ MeV.)

ii) $\sigma_{K\pi}$(tot) was included in the overall fit. She was then able to resolve the ambiguity in favor of the "down" solution.

Meanwhile several groups have attempted to clarify the situation around 1370 MeV. CORDS 72, FRATI 72, and ROUGE 72 give some support to the resonant S-wave interpretation of FIRESTONE 71. The other groups (AGUILAR 72, BUCHNER 72, CRENNELL 72, ENGELMANN 72) agree that the S wave is important but not necessarily resonant. In analogy with the $\pi\pi$ case, where a possible ϵ pole is located several hundred MeV below the observed $\pi^0\pi^0$ peak and quite far from the real axis, the 1370 bump could also be caused by a quite distant κ pole.



XBL 732-2324

S-wave $K\pi$ phase shift. The "up-down" ambiguity now seems resolved by MATISON 72, who performs a partial-wave analysis of $K\pi$ moments extrapolated to the pion pole. In addition, CHUNG 72 imposes positivity on physical region $K\pi$ moments, and finds a narrow resonance most unlikely.

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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)
CORDS    72  COO-1428-308       +CARMONY,LANDER,MEIERE,+    (PURD+UCD+IUPU)
CRENNELL 72 PR D 6 1220         +GORDON,KWAN-WU LAI,SCARR             (BNL)
DIEBOLD  72  BATAV.CONF.        R.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)
ROUGE    72 NP B 46 29          +VIDEAU,VOLTE,DE BRION,+        (EPOL+SACL)
MATISON  72 LBL 1537 (THESIS) REVISED VERSION WILL GO TO PHYS.REV.    LBL

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$K_{A,I=3/2}(1175)$ →

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24  KA 3/2 (1175,JP=  ) I = 3/2

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.
FOR A DISCUSSION SEE ROSENFELD 68 AND
GIACOMELLI 70 WHO CONCLUDES THAT IF THIS
STATE HAS WIDTH NOT LARGER THAN 100 MEV,
THEN ITS PRODUCTION CROSS SECTION IS 1 OR 2
ORDERS OF MAGNITUDE SMALLER THAN THAT OF
NON-EXOTIC K*S.
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                                  REFERENCES FOR KA3/2(1175)

WANGLER  64 PL 9 71             T P WANGLER,A R ERWIN,W D WALKER(WISCONSIN)
MILLER   65 PL 15 74            MILLER,KOVACS,MCILWAIN,PALFREY +   (PURDUE)
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+ZEEM+REHO+EPOL)

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$K_{A,I=3/2}(1265)$

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25  KA 3/2 (1265,JP=  ) I = 3/2

 EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.
 FOR A DISCUSSION SEE ROSENFELD 68.

REFERENCES FOR KA3/2(1265)

FRENCH   67 NC 52A 442       +KINSON+MCDONALD+RIDDIFORD+    (CERN+BIRM)
ROSENFEL 68 PHILA.CONF.P.455 A.H.ROSENFELD                       (LRL)
CHO      70 PL 32 B 409      +DERRICK,JOHNSON,MUSGRAVE,+ (ANL+NWES+KANS)

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Q REGION, $K\pi\pi(1240-1400)$

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28  Q REGION I=1/2
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The main effect in the Q region is a broad bump in the $K\pi\pi$ spectrum between 1200 and 1400 MeV, i. e. not far above $K^*(892)\pi$ threshold, produced by K beams without charge exchange. In particular, it has been observed in coherent K^+d intereactions (FIRESTONE 72) and in coherent interactions on heavy nuclei (BINGHAM 73). The dominant J^P assignment throughout the whole region is 1^+ and $I = \frac{1}{2}$. In addition, evidence for narrower states in the Q region has been reported from non-diffractive reactions (π^-p, $\bar{p}p$).

The following points are relevant to the rather complex situation in the Q region:

- 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 [FIRESTONE 70, BARNHAM 71, BOWLER 71].
- The Q bump was observed with a similar shape in the backward direction by FIRESTONE1 72.
- In addition to the dominant modes $K^*\pi$ and $K\rho$, there is some evidence for a $K\pi\pi$ mode, with the $\pi\pi$ system in an S wave. [ALEXANDER 69, BARNHAM 71, DAVIS 72].
- Analyses of the interference between the $K^*\pi$ and $K\rho$ modes show the relative magnitude and relative phase of the two amplitudes varying with $K\pi\pi$ mass. This is suggestive of the presence of two $J^P = 1^+$ resonances coming possibly from a mixing between the strange members of the $J^{PC} = 1^{++}$ ("A_1") and 1^{+-}(B) nonets [GOLDHABER 67, BARNHAM 71, BOWLER 71, GARFINKEL 71, FIRESTONE 72]. The $K\pi\pi$ mass spectra and the relative magnitudes of the $K^*\pi$ and $K\rho$ amplitudes may be understood from the mixing hypothesis; the relative phase variation has not been explained yet [BOWLER 72].

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                   28  Q  REGION MASS  (MEV)

M   PRODUCED BY BEAMS OTHER THAN K MESONS
M         1242.0      9.0      10.0   ASTIER    69 HBC    0 PBAR P       . 9/69
M   A  THIS IS THE C MESON.
M      45(1300.)                      CRENNELL  67 HBC    0 6 PI- P,LK2PI   7/67
M      40(1300.)                      CRENNELL  72 HBC    0 4.5PI-P,LK2PI  12/72*
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  . 9/69
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)   9/69
M      21 1300.0     10.0             ERWIN     69 HBC    0 3.5 K+P(K* PI)   9/69
M         1281.       7.              FRIEDMAN  69 HBC  --  2.6,2.7 K- P     9/69
M         1300.0     10.0             ABRAMS    70 HBC  +   2.5-3.2 K+ P    11/70
M         1260.      20.              FARBER    70 HBC  +   12.7 K+ P      . 6/70
M        (1325.0)                     DENEGRI   71 DBC   - 12.6 K-D,K 2PI D  5/71
M         . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.9)

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                   28  Q LOW (QA)  MASS  (MEV)

ML F    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        12/72*
ML        1240.0      5.0             BARNHAM   70 HBC  + 10.0 K+P,K 2PI    12/72*
ML        1243.       8.              GARFINKEL 71 DBC  + 9. K+ D           12/72*
ML        1228.      14.              ANDERSON  72 DBC  - 7.3 K- D          12/72*
ML       (1260.)                      DAVIS     72 HBC  + 12. K+ P          12/72*
ML        1234.      12.              FIRESTONE 72 DBC  + 12. K+ D           2/73*
ML        . . . . . . . . . .
ML  AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

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                   28  Q HIGH (QB)  MASS  (MEV)

MH F    FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS
MH
MH     70 1320.0     10.0             SHEN      66 HBC  +   4.6 K+  P       12/72*
MH        1380.0     20.0             ALEXANDER 69 HBC      9.0 K+ P        12/72*
MH        1420.0      5.0             BARNHAM   70 HBC  + 10.0 K+P,K 2PI    12/72*
MH        1344.       8.              GARFINKEL 71 DBC  + 9. K+ D           12/72*
MH        1414.      15.              ANDERSON  72 DBC  - 7.3 K- D          12/72*
MH       (1420.)                      DAVIS     72 HBC  + 12. K+ P          12/72*
MH        1368.      18.              FIRESTONE 72 DBC  + 12. K+ D           2/73*
MH        . . . . . . . . . .
MH  AVERAGE MEANINGLESS (SCALE FACTOR = 4.9)

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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   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  . 9/69
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)   9/69
W      21   40.0     15.0             ERWIN     69 HBC    0 3.5 K+P(K* PI)   9/69
W           51.      22.              FRIEDMAN  69 HBC  -   2.6,2.7 K- P     9/69
W           80.0     20.0             ABRAMS    70 HBC  +   2.5-3.2 K+ P    11/70
W          180.      28.              FARBER    70 HBC  +   12.7 K+ P      . 6/70
W         (180.0)                     DENEGRI   71 DBC  - 12.6 K-D,K 2PI D   5/71
W         . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 4.2)

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                   28  Q LOW (QA)  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  12/72*
WL          40.0     10.0             ALEXANDER 69 HBC      9.0 K+ P        12/72*
WL         110.0     15.0             BARNHAM   70 HBC  + 10.0 K+P,K 2PI    12/72*
WL          70.      26.      18.     GARFINKEL 71 DBC  + 9. K+ D           12/72*
WL         111.      33.              ANDERSON  72 DBC  - 7.3 K- D          12/72*
WL        (120.)                      DAVIS     72 HBC  + 12. K+ P          12/72*
WL         188.      21.              FIRESTONE 72 DBC  + 12. K+ D           2/73*
WL        . . . . . . . . . .
WL  AVERAGE MEANINGLESS (SCALE FACTOR = 3.1)

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                   28  Q HIGH (QB)  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         12/72*
WH         120.0     20.0             ALEXANDER 69 HBC      9.0 K+ P        12/72*
WH         120.0     15.0             BARNHAM   70 HBC  + 10.0 K+P,K 2PI    12/72*
WH         (60.)   OR LESS            GARFINKEL 71 DBC  + 9. K+ D           12/72*
WH          89.      24.              ANDERSON  72 DBC  - 7.3 K- D          12/72*
WH         (80.)                      DAVIS     72 HBC  + 12. K+ P          12/72*
WH         241.      30.              FIRESTONE 72 DBC  + 12. K+ D           2/73*
WH        . . . . . . . . . .
WH  AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)

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                   28  Q REGION PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      Q REGION INTO K*(892) PI                       891+ 139
P2      Q REGION INTO K RHO                            497+ 770
P3      Q REGION INTO K PI                             497+ 139
P4      Q REGION INTO K ETA                            497+ 548
P5      Q REGION INTO K OMEGA                          497+ 783
P6      Q REGION INTO K PI PI                          497+ 139+ 139

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                    28  Q REGION BRANCHING RATIOS

     PRODUCED BY BEAMS OTHER THAN K MESONS
R1      Q REGION INTO (K RHO)/TOTAL (UNITS OF 10**-2)    (P2)
R1            75.0      10.0            ARMENTERO 64 HBC      0.0 PBAR P        6/66
R1         DOMINANT                     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

R3      Q REGION INTO (K+ PI-) / (K+O PIO+ PI-)
R3            (0.2)  OR LESS  CL=.90   CRENNELL  67 HBC    0 6.0 PI-P          7/67

R4      Q REGION INTO (KO PI+ PI- PIO) / (K+O PIO+ PI-)
R4            (0.1)  OR LESS  CL=.90   CRENNELL  67 HBC    0 6.0 PI-P          7/67


     PRODUCED BY K BEAMS
R10     Q REGION INTO (K PI) / (K*(892) PI)                (P3)/(P1)
R10           (0.8)  OR LESS            SHEN       66 HBC     4.6 K+P, 5 BODY  11/67
R10        Q REGION      INTO K*(892) PI AND K RHO (OVERLAPPING BANDS)(P1+P
R10      70   (1.0)                     SHEN       66 HBC  +   4.6 K+P          8/66

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

R12     Q REGION INTO (K PI) / (K*(892) PI)                (P3)/(P1)
R12           (0.30) OR LESS            SHEN       66 HBC  +   4.6 K+P         10/66

R13     Q REGION 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

R14     Q REGION INTO (K PI) / TOTAL                       (P3)
R14           (0.02) OR LESS            BERLINGHI 67 HBC  +   12.7 K+ P        11/67
R14           (0.02) OR LESS  CL=.95   BARTSCH   68 HBC   - 10.0 K- P

R15     Q REGION INTO (K ETA) / TOTAL                      (P4)
R15           (0.02) OR LESS            BERLINGHI 67 HBC  +   12.7 K+ P        11/67

R16     Q REGION 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)

R18     Q REGION INTO (K PI) / (K*(892) PI)                (P3)/(P1)
R18           (0.21) OR LESS            DE BAERE  67 HBC  +   3.5 K+ P         11/66

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      POSSIBLY 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                                      1/73*

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                       REFERENCES FOR Q REGION

        PRODUCED BY BEAMS OTHER THAN K MESONS

ARMENTER 64 DUBNA CONF 1 577  ARMENTEROS,EDWARDS,D-ANDLAU +   (CERN+CDEF)
    ALSO 64 DUBNA CONF 1 617  R ARMENTEROS (RAPPORTEUR)
    ALSO 66 PR  145  1095     BARASH,KIRSCH,MILLER,TAN         (COLUMBIA)
CRENNELL 67 PRL 19  44        +KALBFLEISCH,LAI,SCARR,SCHUMANN      (BNL)I
ASTIER   69 NP B 10 65        +MARECHAL,MONTANET,+  (CDEF+CERN+IPNP+LIVP)IJP
BETTINI  69 NC 62 A 1038      +CRESTI,LIMENTANI,BERTAUZA,BIGI+(PADO+PISA)I

        PRODUCED BY K BEAMS

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
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+   (JOHNHOPK)  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)
BARBARO  69 PRL 22 1207       BARBARO-GALTIERI,DAVIS,FLATTE,+        (LRL)
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                 (ROCH)  1+
FIRESTON 70 PHILAD.CONF.P.229 A. FIRESTONE REVIEW                    (LRL)

BARNHAM  71 NP B25 49         +COLLEY,GRIFFITHS,ALPER, +  (BIRM+GLAS+OXF)
BOWLER   71 BOLOGNA CONF.PROC M.G.BOWLER  INTRODUCTORY TALK       (OXFORD)
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+
SLATTERY 71  UR-875-332(PREP) P.SLATTERY,A REVIEW OF STRANGE MESONS(ROCH)

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       +ALSTON,BARBARO,FLATTE,FRIEDMAN,LYNCH+(LBL)
FIRESTON172 NP B 47 348       A.FIRESTONE                            (CIT)
FIRESTON 72 PR D 5 505        FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)
FRATI    72 PR D 6 2361       +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
HAATUFT  72 NP B 48 78        +ARNOLD,HAGUENAUER,+  (BERG+STRB+EPOL+MADR)
BINGHAM  73 NP B (TO APPEAR)  +FARWELL,+      (LBL,ORSAY,BNL,SACLAY,MILAN)
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K_N(1420)

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22  KN (1420,JP=2+) I=1/2

JP = 3- IS UNLIKELY BUT NOT YET COMPLETELY RULED OUT.

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                    22  KN(1420) MASS (MEV)

M   FOR DIFFICULTIES IN MEASURING MASS DIFFERENCE, SEE TYPED NOTE UNDER K*

M   CHARGED ONLY, WITH FINAL STATE K PI
M          1440.       24.0      40.    DE BAERE  67 HBC  + 3.5 K+P (K+ PIO) 10/66
M          1423.       21.              ADERHOLZ  68 HBC  -  10 K- P (K PI)    6/68
M          1401.0      20.0             SCHWEINGR 68 HBC  -  4.1 K- P (K PI)   2/72
M          1427.0       9.0             SCHWEINGR 68 HBC  -  5.5 K- P (K PI)   9/67
M          1425.0      15.0             BISHOP    69 HBC  +  3.5 K+ P          9/69
M          1416.0      10.0             CRENNELL  69 DBC  -  3.9 K-N (KOPI-)   7/69
M          1414.       11.              LIND      69 HBC  +  9. K+ P(KO PI+)   9/69
M          1430.       10.              ABRAMS    70 HBC  + 2.5-3.2 K+P,K2PI  11/70
M     1400 1420.0       3.1             AGUILAR1  71 HBC  -  3.9,4.6 K- P     11/71
M      200 1425.        6.              BARNHAM   71 HBC  + K+ P,KO PI+ P      1/72
M          . . . . . . . . . .
M   AVG    1421.3       2.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M   CHARGED ONLY, WITH OTHER FINAL STATES
M          1400.0      20.0             BADIER    65 HBC  -  3.  K- P (K*PI) 10/66
M       20 1440.0      20.0             DUBAL     68 MMS  -  11.5 K- P         6/68
M  B   240 1396.        6.              BASSOMPIE 69 HBC  +   5 K+P (K 2PI)   11/69
M         (1411.)      (7.)             FRIEDMAN  69 HBC  -  2.7 K-P (K 2PI)   2/72
M          . . . . . . . . . .
M   AVG    1399.7       8.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)

M   CHARGED AND NEUTRAL
M          1404.0      15.0             FOCARDI   65 HBC  -0 3.  K- P (K PI) 10/66
M          1390.0      30.0             SHEN      66 HBC  + 0 4.6 K+ P (K PI) 10/66
M          1430.0      10.0             SHEN      66 HBC  + 0 4.6 K+ P (K*PI) 10/66
M          1423.0       7.0             BASSANO   67 HBC  -0 4.6, 5.0 K- P   10/67
M          1420.0      10.0             GOLDHABER 67 HBC     9.0 K+ P(K 2PI) 10/67
M          . . . . . . . . . .
M   AVG    1421.2       4.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M   NEUTRAL ONLY
M          1446.0       7.9             DAHL      67 HBC   0 4.PI- P (KPI)    10/66
M          1425.0      15.0             KANG      68 HBC   0 4.6 K- P          7/69
M          1405.0      18.0             SCHWEINGR 68 HBC   0 4.1 K- P (K PI)   9/67
M          1397.0      19.0             SCHWEINGR 68 HBC   0 5.5 K- P (K PI)   9/67
M  B   420 1422.        5.              BASSOMPIE 69 HBC   0 5 K+P (K PI)     11/69
M  B BASSOMP. ERRORS ENLARGED BY US TO  GAMMA/SQRT(N). SEE K* TYPED NOTE.    11/69
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          . . . . . . . . . .
M   AVG    1422.8       2.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
                       (SEE IDEOGRAM BELOW )
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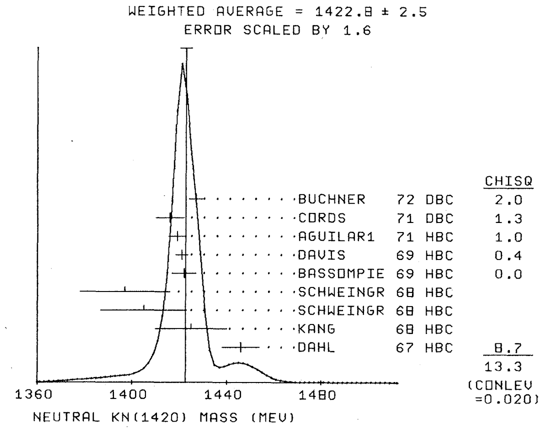

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                    22  KN(1420) WIDTH (MEV)

W   CHARGED ONLY, WITH FINAL STATE K PI
W           175.       57.              ADERHOLZ  68 HBC  -  10 K- P (K PI)    6/68
W           110.0      25.0             BISHOP    69 HBC  +  3.5 K+ P          9/69
W            96.       18.              LIND      69 HBC  +  9. K+ P           5/70
W            80.0      20.0             ABRAMS    70 HBC  + 2.5-3.2 K+P,K2PI  11/70
W     1400   94.7      15.1     12.5    AGUILAR1  71 HBC  -  3.9,4.6 K- P     11/71
W      200  115.       20.              BARNHAM   71 HBC  + K+ P,KO PI+ P      1/72
W          . . . . . . . . . .
W   AVG      99.1       8.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W   CHARGED ONLY, WITH OTHER FINAL STATES
W           105.0      30.0             BADIER    65 HBC  -  3.0 K-P           6/66
W  B   240  110.       25.              BASSOMPIE 69 HBC  +  5 K+P (K 2PI)    11/69
W          (43.)      (13.)             FRIEDMAN  69 HBC  -  2.7 K-P (K 2PI)   2/72
W          . . . . . . . . . .
W   AVG     108.0      19.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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Data Card Listings

For notation, see key at front of Listings.

Mesons

$K_N(1420)$, $K_N(1660)$

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W   CHARGED AND NEUTRAL
W           92.0      14.0            FOCARDI   65 HBC  -0 3.0 K- P (K PI)
W           75.0      25.0            SHEN      66 HBC  + 04.6 K+ P          8/66
W           65.0      20.0            BASSANO   67 HBC  -0 4.6, 5.0 K- P    10/67
W           80.0      20.0            GOLDHABER 67 HBC     9.0 K+ P(K 2PI) 10/67
W          107.0      20.0            SCHWEINGR 68 HBC  -0 4.1+5.5 K-P      9/67
W               . . . . . . . . .
W   AVG     85.9       8.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W   NEUTRAL ONLY
W           61.0      24.0            DAHL      67 HBC   0 3.8-4.2 PI- P    9/66
W          116.0      17.0            KANG      68 HBC   0 4.6 K- P         7/69
W  B   420 110.       21.             BASSOMPIE 69 HBC   0 5 K+P (K PI)    11/69
W  B          ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE K* TYPED NOTE.
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     600  144.       22.             CORDS     71 DBC  0 9. K+ N,K+ PI- P  2/72
W  B 1100  109.       12.             BUCHNER   72 DBC  0 4.6 K+ N,K+ PI-P 12/72*
W               . . . . . . . . .
W   AVG    108.4       6.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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                     22  KN(1420) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      KN(1420) INTO K PI                             493+ 139
P2      KN(1420) INTO K*(892) PI                       891+ 139
P3      KN(1420) INTO K RHO                            493+ 770
P4      KN(1420) INTO K OMEGA                          493+ 783
P5      KN(1420) INTO K ETA                            493+ 548

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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 5
 P 1 .5495+-.0274
 P 2   -.2293   .2945+-.0247
 P 3   -.3950     -.3925   .0923+-.0241
 P 4   -.2443     -.2458     -.1182  .0440+-.0166
 P 5   -.4097     -.2442     -.0787    -.0502  .0197+-.0200


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                     22  KN(1420) BRANCHING RATIOS

R1      KN(1420) INTO (K PI)/TOTAL                       (P1)
R1  R        (0.37)   (0.19)          BADIER    65 HBC      3.0 K-P         6/66
R1  R        (0.39)   (0.11)          BASSANO   67 HBC  -   4.6, 5.0 K- P  10/67
R1  R         WE CANNOT USE THIS STATISTICALLY REDUNDANT RATIO. AUTHORS
R1  R         OBTAIN IT MERELY BY SUBTRACTING FROM UNITY THEIR
R1  R         MEASUREMENTS OF OTHER RATIOS.
R1              . . . . . . . . .
R1  FIT       0.550    0.027  FROM FIT

R2      KN(1420) INTO (K*(892) PI) / TOTAL               (P2)
R2  Q         (.41)   (0.14)          BADIER    65 HBC      3.0 K-P         6/66
R2  Q        (0.47)   (0.10)          BASSANO   67 HBC  -   4.6, 5.0 K- P  10/67
R2              . . . . . . . . .
R2  FIT       0.295    0.025  FROM FIT

R3      KN(1420) INTO (K RHO)/TOTAL                      (P3)
R3  Q        (0.14)   (0.05)          BADIER    65 HBC      3.0 K-P         6/66
R3  Q        (0.14)   (0.10)          BASSANO   67 HBC   0 4.6, 5.0 K- P   10/67
R3              . . . . . . . . .
R3  FIT       0.092    0.024  FROM FIT

R4      KN(1420) INTO (K OMEGA)/TOTAL                    (P4)
R4            0.07     0.04           BADIER    65 HBC      3.0 K-P         6/66
R4              . . . . . . . . .
R4  FIT       0.044    0.017  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5      KN(1420) INTO (K ETA)/TOTAL                      (P5)
R5            0.02     0.02           BADIER    65 HBC      3.0 K-P         6/66
R5           (0.025)OR LESS           BASSOMPIE 69 HBC      5.0 K+ P        9/68
R5              . . . . . . . . .
R5  FIT       0.020    0.020  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6      KN(1420) INTO (K*(892) PI) / (K PI)              (P2)/(P1)
R6      6     0.33     0.33           CHUNG     65 HBC  + 0  3.9-4.2 PI- P  8/66
R6            0.65     0.20           SHEN      66 HBC    0  N* PRODUCED   10/66
R6  Q        (0.63)   (0.20)          SHEN      66 HBC  +    NO N* PRODUCED 10/66
R6            0.52     0.12           SCHWEINGR 68 HBC   0 4.1+5.5 K- P    10/67
R6  B        (0.9)    (0.2)           BASSOMPIE 69 HBC  + 0 5 K+P           1/73*
R6  B   SUPERSEDED BY CHARRIERE 72
R6  Q   84   (0.93)   (0.11)          BISHOP    69 HBC      3.5 K+ P        9/69
R6            0.47     0.08           AGUILAR1  71 HBC      3.9,4.6 K- P   11/71
R6            0.78     0.15           CHARRIERE 72 HBC   0 5. K+ P,K P 3PI  1/73*
R6              . . . . . . . . .
R6  AVG       0.537    0.058   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6  FIT       0.536    0.057  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R7      KN(1420) INTO (K OMEGA) / K PI                   (P4)/(P1)
R7           (0.08) OR LESS           SHEN      66 HBC      4.6 K+P         8/66
R7           (0.2)  OR LESS           BASSOMPIE 69 HBC  +   5 K+ P          9/69
R7            0.13     0.07           BASSOMPIE 69 HBC   0 5 K+ P           9/69
R7            0.05     0.04           AGUILAR1  71 HBC      3.9-4.6 K- P   11/71
R7              . . . . . . . . .
R7  AVG       0.070    0.035   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R7  FIT       0.080    0.031  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R8      KN(1420) INTO (K RHO) / (K PI)                   (P3)/(P1)
R8           (0.09) OR LESS           CHUNG     65 HBC  + 0  3.9-4.2 PI- P  8/66
R8            0.26     0.16           SCHWEINGR 68 HBC   0 4.1+5.5 K- P    10/67
R8           (0.2)  OR LESS           BASSOMPIE 69 HBC  +   5 K+ P          9/69
R8           (0.3)  OR LESS           BASSOMPIE 69 HBC   0 5 K+ P           9/69
R8  Q   15   (0.11)   (0.06)          BISHOP    69 HBC      3.5 K+ P        9/69
R8            0.16     0.05           AGUILAR1  71 HBC      3.9,4.6 K- P   11/71
R8              . . . . . . . . .
R8  AVG       0.169    0.048   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  FIT       0.168    0.048  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R9      KN(1420) INTO (K RHO) / (K*(892) PI)                     (P3)/(P2)
R9           (0.39) OR LESS            BASSOMPIE 67 HBC  +   5. K+ P            9/67
R9           (0.40) OR LESS  CL=.90    FIELD     67 HBC   - 3.8 K- P            6/67
R9              . . . . . . . . .
R9  FIT       0.313    0.095  FROM FIT

R10     KN(1420) INTO (K OMEGA) / (K*(892) PI)                   (P4)/(P2)
R10 Q        (0.10)   (0.04)           FIELD     67 HBC   - 3.8 K- P            6/67
R10             . . . . . . . . .
R10 FIT       0.149    0.061  FROM FIT

R11     KN(1420) INTO (K ETA) / (K*(892) PI)                     (P5)/(P2)
R11 Q        (0.07)   (0.04)           FIELD     67 HBC   - 3.8 K- P            6/67
R11             . . . . . . . . .
R11 FIT       0.067    0.069  FROM FIT

R12     KN(1420) INTO (K ETA) / (K PI)                           (P5)/(P1)
R12          (0.02) OR LESS            BISHOP    69 HBC      3.5 K+ P           9/69
R12          (0.04) OR LESS  CL=.95    AGUILAR1  71 HBC      3.9-4.6 K- P      11/71
R12             . . . . . . . . .
R12 FIT       0.036    0.037  FROM FIT

R    Q   FOLLOWING SUGGESTION 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.


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                         REFERENCES FOR KN(1420)

BADIER   65 PL 19 612         BADIER,DEMOULIN,GOLDBERG+(EPOL+SACL+ZEEMAN)
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
    ALSO 69 DE BAERE
    ALSO 70 DE BAERE
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)
    ALSO 70 DE BAERE
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)
BIRMINGH 70  KIEV CONF.       ASTIER RAPPORTEURS TALK     (BIRM+GLAS+OXF)
DE BAERE 70  CERN PHYS 70 41  +DEBAISIEUX,DE WOLF,DUFOUR,+    (BELG+CERN)

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)
SLATTERY 71  UR-875-332(PREP) P.SLATTERY,A REVIEW OF STRANGE MESONS(ROCH)

BUCHNER  72 NP B 45 333       +DEHM,CHARRIERE,CORNET,+   (MPIM+CERN+BRUX)
CHARRIER 72 NP B 51 317       CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)
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+ZEEM)
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$K_N(1660)$

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27  KN (1660, JP=  ) I = 1/2

    EVIDENCE NOT COMPELLING, OMITTED FROM TABLE

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                     27  KN(1660) MASS (MEV)

M          (1660.0)                    CARMONY   67 HBC   -  3.8 K-P,OMEGA K 11/67
M           1660.0     10.0            JOBES     67 HBC  +   5. K+ P          11/67
M     J     CLAIMED BY JOBES IN (K PI), (K*(892) PI), AND (KN(1420) PI)
M     J     MODES. K PI BUMP INTERFERES MOSTLY WITH DELTA(1236).
M          (1660.)                     CHARRIERE 72 HBC   0 5. K+ P,K P 3PI   1/73*

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                     27  KN(1660) WIDTH (MEV)

W             60.0     20.0            JOBES     67 HBC  +   5. K+ P          11/67
W            (60.)                     CHARRIERE 72 HBC   0 5. K+ P,K P 3PI   1/73*

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                     27  KN(1660) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      KN(1660) INTO K PI                              493+ 139
P2      KN(1660) INTO K PI PI                           493+ 139+ 139
P3      KN(1660) INTO K*(892) PI                        891+ 139
P4      KN(1660) INTO KN(1420) PI                      1421+ 139

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Mesons

K_N(1660), K_N(1760), L(1770), K_N(1850), K^*(2200)

Data Card Listings

For notation, see key at front of Listings.

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                              REFERENCES FOR KN(1660)

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 72 NP B 51 317       CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)

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K_N(1760)

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                60  KN (1760,JP=  )

                    NEEDS FURTHER CONFIRMATION.OMITTED FROM THE TABLE.
                    FAVORED JP IS 3- , I=1/2 .

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                    60  KN(1760) MASS (MEV)

M   C   76(1753.)    (12.)            CARMONY   71 DBC    0 9. K+ N        11/71

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                    60  KN(1760) WIDTH (MEV)

W   C   76  (60.)    (20.)            CARMONY   71 DBC    0 9. K+ N        11/71
W   C  DISAGREEMENT BETWEEN THE FIT AND DATA ON BOTH SIDES OF THE SIGNAL   11/71

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                    60  KN(1760) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1     KN(1760) INTO K PI                                493+ 139
P2     KN(1760) INTO K*(892) PI                          891+ 139
P3     KN(1760) INTO K RHO                               493+ 770
P4     KN(1760) INTO KN(1420) PI                        1421+ 139
P5     KN(1760) INTO K PI PI                             493+ 139+ 139

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                    60  KN(1760) BRANCHING RATIOS

R1     KN(1760) INTO (K PI)/(K*(892) PI + K RHO)         (P1)/(P2+P3)
R1  E       (0.40)    (0.10)          CARMONY   71 DBC    0 9. K+ N        11/71

R2     KN(1760) INTO (K*(892) PI)/(K PI PI)              (P2)/(P5)
R2  E       (0.40)    (0.15)          CARMONY   71 DBC    0 9. K+ N        11/71

R3     KN(1760) INTO (K RHO)/(K PI PI)                   (P3)/(P5)
R3  E       (0.60)    (0.25)          CARMONY   71 DBC    0 9. K+ N        11/71

R4     KN(1760) INTO (K*(892) PI + K RHO)/(K PI PI)      (P2+P3)/(P5)
R4  E       (1.)      (0.12)          CARMONY   71 DBC    0 9. K+ N        11/71

R5     KN(1760) INTO (KN(1420) PI)/(K PI PI)             (P4)/(P5)
R5  E       (0.06) OR LESS            CARMONY   71 DBC    0 9. K+ N        11/71
R5  E  DIFFICULT BACKGROUND SUBTRACTION . ERRORS STATISTICAL ONLY .        11/71

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                              REFERENCES FOR KN(1760)

CARMONY  71 PRL 27 1160       +CORDS,CLOPP,ERWIN,MEIERE,+ (PURD+UCD+IUPU)

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L(1770)

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                    23  L (1770, JP=  ) I = 1/2

                    FOR REVIEWS SEE HUGHES 71,SLATTERY 71 .

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                    23  L 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   B      (1785.0)   (12.0)           BARTSCH   68 HBC      10.0 K- P       11/71
M   B       INCLUDED IN BARTSCH 70                                           11/71
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)

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                    23  L 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   B      (127.0)    (43.0)           BARTSCH   68 HBC      10.0 K- P       11/71
W   B       INCLUDED IN BARTSCH 70                                           11/71
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)
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                    23  L PARTIAL DECAY MODES
                                                         DECAY MASSES
P1     L INTO K PI PI                                    497+ 134+ 134
P2     L INTO KN(1420) PI                                134+1421
P3     L INTO K PI PI PI                                 497+ 134+ 134+ 134
P4     L INTO K*(892) PI                                 891+ 134
P5     L INTO K*(892) RHO                                891+ 770
P6     L INTO K*(892) OMEGA                              891+ 783
P7     L INTO K*(892) PI PI                              891+ 134+ 134
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                    23  L BRANCHING RATIOS

R1     L INTO (KN(1420) 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*                                       12/72*
R1   R LESS THAN 1.0 SEEMS TO BE ESTABLISHED.
R1   R FOR DISCUSSION OF THE EXPERIMENTAL EVIDENCE ON OTHER DECAY            11/71
R1   R MODES SEE HUGHES 71,SLATTERY 71 .                                     11/71

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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)
DENEGRI  68 PRL 20 1194       +CALLAHAN+ETTLINGER+GILLESPIE+         (JHU)
BARTSCH  68 NP B8 9           +COCCONI,+        (AACH+BERL+CERN+LOIC+VIEN)

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)
CHIEN    70  PHILA.CONF.P.275 C.Y.CHIEN                    (JOHNS HOPKINS)
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
HUGHES   71 BOLOGNA CONF.PROC I.S.HUGHES,TALK AT BOLOGNA CONF.  (GLASGOW)
SLATTERY 71  UR-875-332(PREP) P.SLATTERY,A REVIEW OF STRANGE MESONS(ROCH)

ANDERSON 72 PR D 6 1823       +FRANKLIN,GODDEN,KOPELMAN,LIBBY,TAN  (COLO)
BLIEDEN  72 PL 39 B 668       +FINOCCHIARO,BOWEN,EARLES,+      (STON+NEAS)
CHARRIER 72 NP B 51 317       CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)
FIRESTON 72 PR D 5 505        FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)

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K_N(1850)

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                61  KN (1850,JP=  )

          STRUCTURE IS SEEN IN THE K PI SCATTERING ANGULAR DISTRIBUTION
          AT MASSES NEAR 1850 MEV.THE MOST SIMPLE EXPLANATION INVOLVES
          A RAPIDLY INCREASING F-WAVE AMPLITUDE,POSSIBLY INDICATING
          PRESENCE OF A JP=3- RESONANCE.
          NEEDS FURTHER CONFIRMATION. OMITTED FROM THE TABLE.

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                    61  KN(1850) MASS (MEV)

M   I     (1850.)   APPROX.           FIRESTONE 71 DBC    0 12.K+ N,K+ PI-P 11/71

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                    61  KN(1850) WIDTH (MEV)

W   I      (300.)   APPROX.           FIRESTONE 71 DBC    0 12.K+ N,K+ PI-P 11/71
W   I      APPARENT INTERFERENCE WITH OTHER AMPLITUDES PRECLUDES              11/71
W   I      PRECISE DETERMINATION .                                            11/71

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                              REFERENCES FOR KN(1850)

FIRESTON 71 PL 36 B 513       FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)

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K^*(2200)

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                    40  K* (2200,JP=  )

                    ENHANCEMENT SEEN IN (ANTIHYPERON-NUCLEON) MASS
                    NEAR THRESHOLD.INTERPRETATION UNCERTAIN.
                    OMITTED FROM 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         11/71

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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         11/71

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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)

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Data Card Listings

For notation, see key at front of Listings.

K*(2800)

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                                 62  K* (2800,JP=  )
                            NEEDS FURTHER CONFIRMATION.OMITTED FROM THE TABLE.

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                   62  K*(2800) MASS (MEV)

M    H  59(2800.)                   HUGHES    71 HBC  +  10.K+P,P MMS+    11/71

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                   62  K*(2800) WIDTH (MEV)

W    H  59  (40.)   OR LESS         HUGHES    71 HBC  +  10.K+P,P MMS+    11/71
W    H     ONLY SEEN IN MISSING MASS DISTRIBUTION,NOT IN FITTED EVENTS.    11/71
W    H     PROBABLY DECAYS INTO (3 CHARGED + 2 OR MORE NEUTRAL) PARTICLES  11/71

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                              REFERENCES FOR K*(2800)

HUGHES   71  PREPRINT          +MC≠CORMICK,PROCTER,TURNBULL      (GLASGOW)

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Note on Speed Plots

In the discussion which follows, we use the term "speed plot" to indicate a plot showing the variation with C. M. energy m of the derivative $|dT/dm|$ of a partial-wave amplitude T. (See section IV C of the main text.) In principle such plots are a very sensitive and useful means of searching for a resonance. A rapid increase in speed followed by a rapid decrease is certainly a good indication of the presence of a resonance. In practice these plots must be judiciously used because:

1) The values of dT/dm are sensitive to variations in T. It is difficult enough to determine T(m); finding its derivative is necessarily more difficult.

2) Once the speed plot tells us that a resonance is present, the determination of precise parameters from such a plot requires additional considerations:

a) the maximum of the speed is not necessarily at the resonance mass,

b) the width cannot simply be obtained by the relation $|dT/dm|_{m=M} = 2x/\Gamma$.

Consider for example the P_{33} partial-wave amplitude in π-N scattering. Since its elasticity (x) is one, we have

$$T(m) = \frac{\Gamma(m)/2}{M-m-i\Gamma(m)/2} . \qquad (1)$$

If we let $\Gamma'(m) = d\Gamma/dm$, then we find that

$$\text{"Speed"} = \left|\frac{dT}{dm}\right| = \frac{2}{\Gamma}\,\frac{1+(M-m)\Gamma'/\Gamma}{1+4(M-m)^2/\Gamma^2} . \qquad (2)$$

To estimate where Eq. (2) is maximum, we let $m = M + \delta$ and find that for small δ,

$$\frac{d}{dm}\left|\frac{dT}{dm}\right| = -\frac{16}{\Gamma^3}\left(\frac{\Gamma\Gamma'}{8} + \delta\right) + \mathcal{O}(\delta^2) . \qquad (3)$$

Since all reasonable parametrizations of Γ(m) agree that $\Gamma' \geqslant 0$, we may conclude that the "speed" will have its maximum value at an energy about $\Gamma\Gamma'/8$ less than the resonant value, m=M.

This effect is illustrated in Fig. 1, which is taken from UCRL-20030 πN.[1] For the P_{33} partial wave, the CERN experimental and CERN Kirsopp solutions indicate the instability of $|dT/dm|$ in the region of a resonance (the other solutions are "smooth" by the nature of the analysis). In addition, each of the plots, quite consistently, gives $2/\Gamma \approx 16\ \text{GeV}^{-1}$ at a resonant mass of ~1236 MeV. This corresponds to a width at resonance of ~125 MeV. The speed, however, peaks some 10 to 15 MeV lower in mass and at a value of ~18.5 GeV^{-1}. Hence, were we to estimate the mass and width of the 33-resonance from the maximum speed, we would get M ≈ 1220 MeV and Γ = 108 MeV. For additional discussion on the mass and width of this resonance, see the mini-review at the beginning of the Δ(1236) listings.

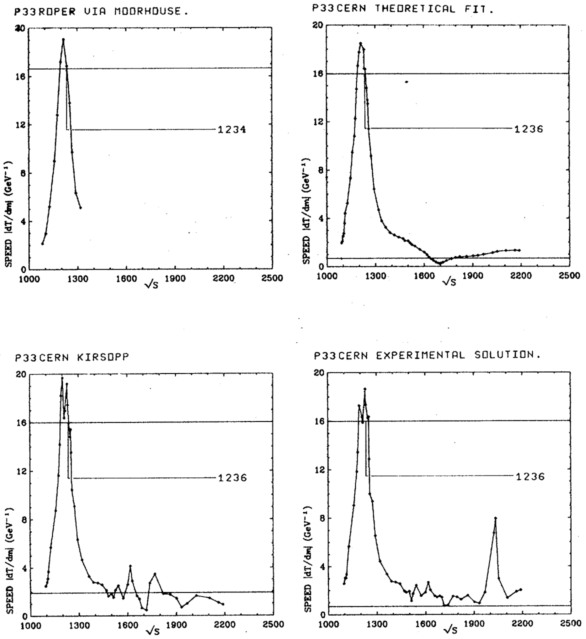

Fig 1. Speed plots as computed from four solutions compiled in Ref. 1. ($\sqrt{s}$ = m = c. m. energy in MeV)

Reference

1. D. Herndon, et al., "πN Partial-Wave Amplitudes, a Compilation," UCRL-20030 πN, Feb. 1970.

Note on N's and Δ's: Partial-Wave Analyses

There now exist complete partial-wave analyses performed by two groups after the beginning of 1970. The older analysis, AYED 70, is an update of the previous Saclay analyses. These are essentially energy-independent solutions selected on the basis of various energy "smoothness" criteria. A more recent analysis, ALMEHED 72, is a continuation of the "CERN group" program, which uses "smoothness" criteria supplemented by constraints from partial-wave dispersion relations. For a discussion of earlier partial-wave analyses see Refs. 1 and 2.

For the purposes of comparison, we show Argand plots of the solutions in Figs. 1 and 2. The arrowheads on the lines connecting points at discrete energies are 5 MeV long, and are spaced at 20 MeV intervals. The AYED 70 analysis extends in c.m. energy from 1400 to 2450 MeV; the ALMEHED 72 analysis, from 1100 to 2200 MeV. We have indicated the energies where AYED 70 and ALMEHED 72 claim resonances, and in the case of ALMEHED 72 we have also indicated the grade, A through D, assigned to each of their resonances by this group. In addition, we also show in Figs. 3 and 4 plots of δ and η versus c.m. energy ($\sqrt{s}$) for the same two solutions.

The Saclay group has presented preliminary results on a new πN phase-shift analysis in an unpublished report to the 1972 Batavia conference. This analysis includes recent data, and improves some of the methods of the earlier analysis. These improvements include checking the final results for smoothness in energy of invariant amplitudes at fixed t and the unmeasured charge exchange polarization Legendre coefficients, as well as a qualitative check of the final results for consistency with an unsubtracted forward dispersion relation for the B amplitude. The main differences between the resonance parameters extracted from this new analysis (AYED 72) and those of ALMEHED 72 are summarized below. None of the states listed below were reported by AYED 70 except the P_{11} with M = 1461, Γ = 164, and x = 0.56.

	ALMEHED 72			AYED 72		
Wave	M	Γ	x	M	Γ	x
S_{11}	2100	200	0.5	2195	280	0.173
P_{11}	1470	220	0.65	1427	236	0.524
				1530	65	0.120
D_{13}				1730	130	0.1
D_{15}	2100	150	0.2	2055	170	0.09
F_{17}	2000	200	0.15	2048	183	0.058
G_{19}				2130	250	0.08
D_{35}	2200	600	0.25	1870	160	0.095

Of particular interest are the new results on the P_{11} and D_{13} partial waves. Previous partial-wave analyses have seen a single fairly elastic ($x \gtrsim 0.5$) P_{11}(1470) resonance in the mass range 1440-1500 MeV, while many production experiments have observed a bump in the invariant mass distribution tending to be somewhat narrower and at somewhat lower mass than that obtained from partial-wave analysis. The Saclay group now claims two states. As for the D_{13}, the quark model predicts an inelastic resonance in the neighborhood of 1700 MeV, and the existence of such a state is now indicated by isobar model fits to $\pi N \rightarrow \pi\pi N$ (see the mini-review on this subject) and by AYED 72. The effect now claimed by AYED 72 to be the D_{13}(1700) is visible in both the ALMEHED 72 and AYED 70 solutions (see Figs. 3 and 4) in the 1700 MeV region.

The remaining new results listed above are five high mass resonances, four of which were seen by ALMEHED 72, but none by the earlier Saclay analysis. In the case of the D_{35} it may well be that ALMEHED 72 and AYED 72 are reporting completely different effects.

Spread in Values of Resonance Parameters

Values of masses, widths, and branching ratios can be obtained only from phase-shift analyses. In production experiments, in fact, it is seldom clear which of the many states at similar masses is being observed. In addition to the two complete phase-shift analyses discussed above, we have other analyses, done by using somewhat incomplete data, by several different groups, but we are quite far from having reliable masses and widths derived therefrom.

There are essentially two problems in obtaining reliable resonance parameters. First there is often disagreement as to just what the values of the phase shifts (η's and δ's) are. This problem is obviously related to the quality and quantity of the data and to the procedures used to determine or choose the phase shifts. Secondly, even if smooth curves were available for the phase shifts, there would still be some ambiguity in deciding what the resonant parameters are. We might hope that some sort of energy-dependent fit to the smooth phase shifts would yield unique parameters. Unfortunately, however, a sufficiently clever combination of background and/or resonances could fit the phase shifts, satisfy elastic unitarity, and still yield the wrong parameters. (See the Comments on the Mass and Width of Δ(1236), below.)

We list the values of M, Γ and x quoted by the various authors with a comment on the method used to derive such parameters. We now discuss briefly the different methods used. AYED 70 analyze their

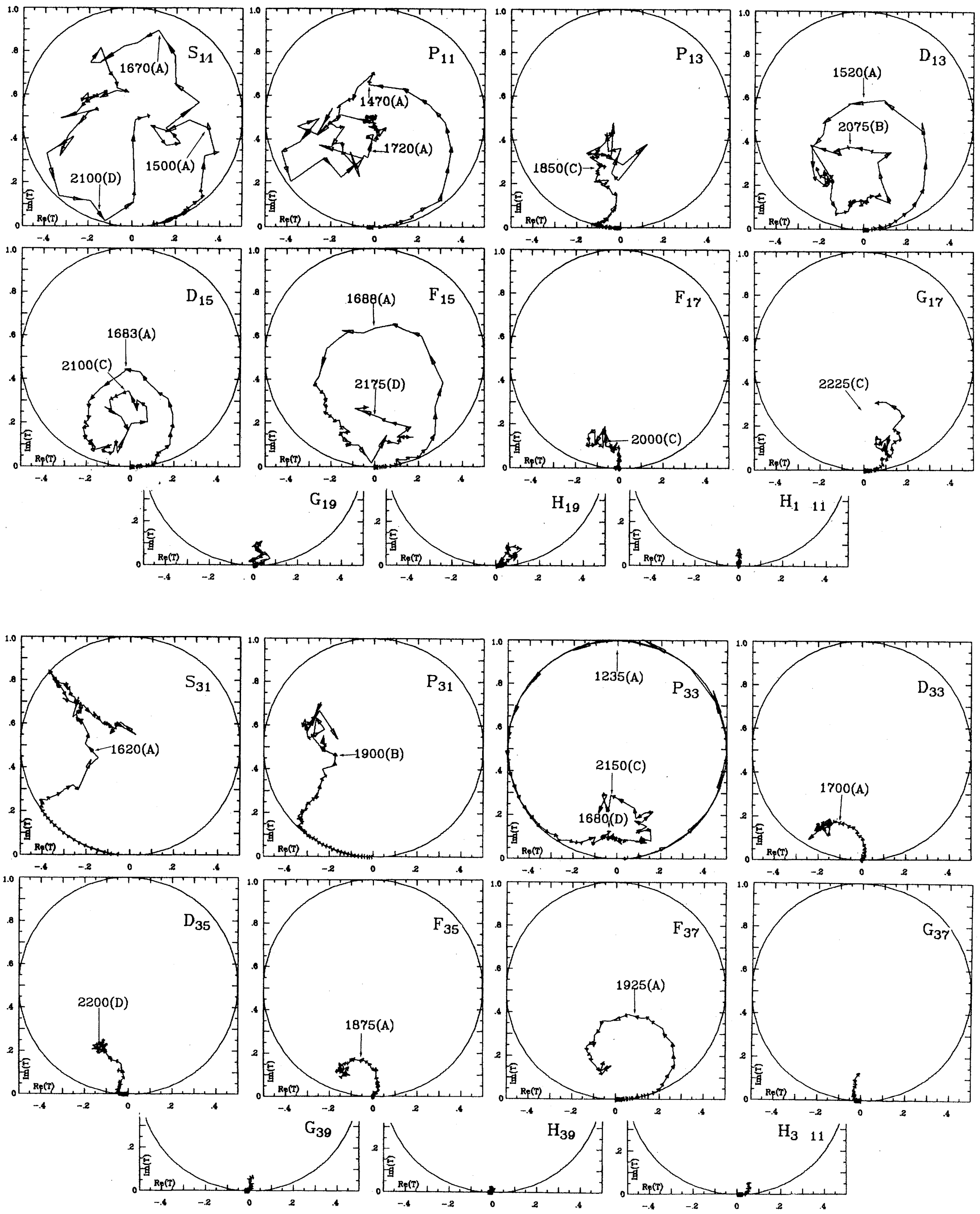

Fig. 1. πN Argand plots from the solution of ALMEHED 72. The bases of the arrowheads are 20 MeV apart; the end point is at ~2200 MeV. The numbers are the resonant masses claimed by ALMEHED 72, and the letters indicate their evaluation of the resonance.

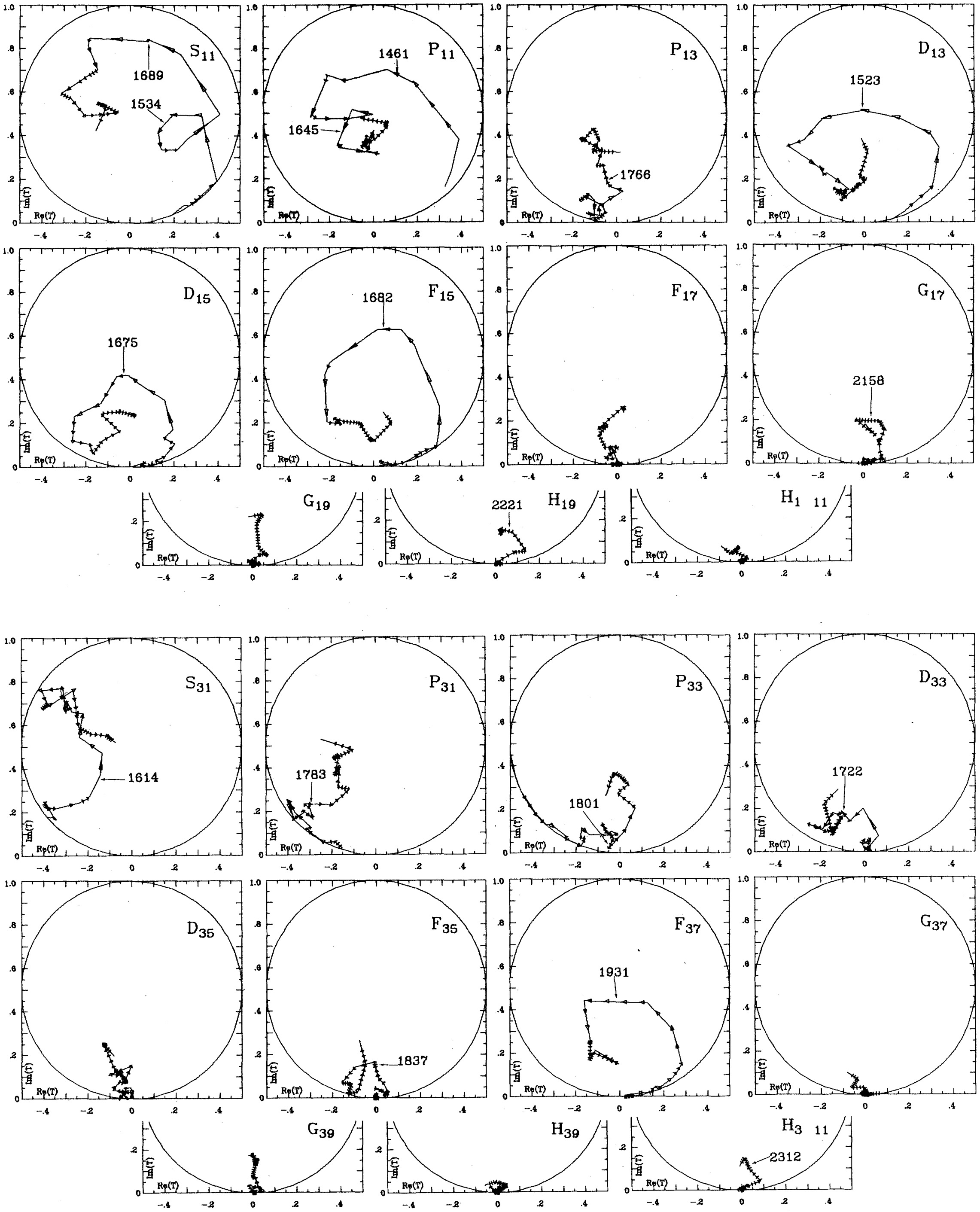

Fig. 2. πN Argand plots from the "minimum surface" solution of AYED 70 [Phys. Letters 31B, 598 (1970)]. To conserve space, we arbitrarily do not show the "minimum path" solution; it is not significantly different. The bases of the arrowheads are 20 MeV apart; the last point is at ~2400 MeV.

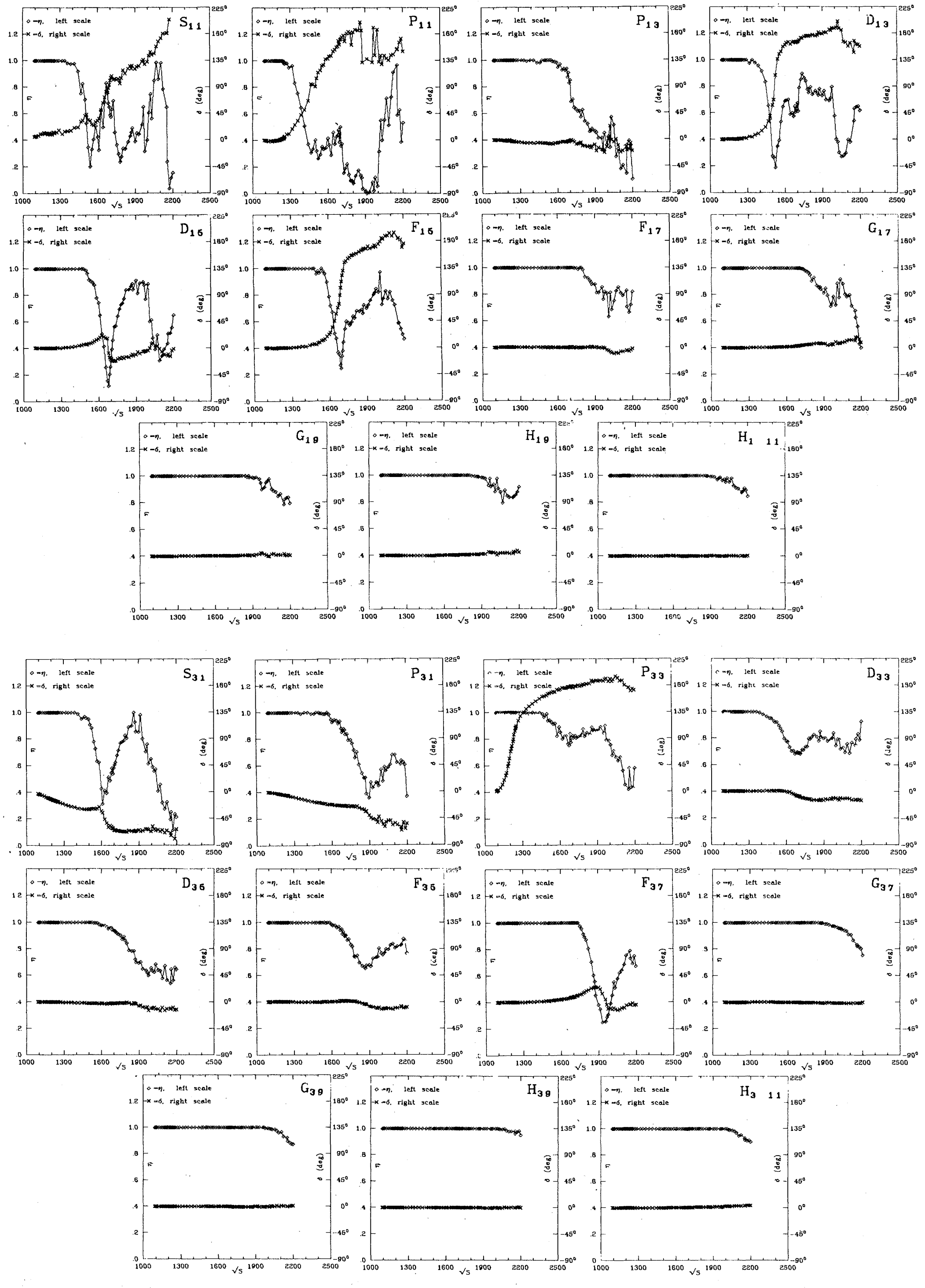

Fig. 3. δ and η versus c.m. energy (in MeV) from the πN partial-wave analysis solution of ALMEHED 72. × denotes δ (right-hand scale), ◇ denotes η (left-hand scale).

Data Card Listings

For notation, see key at front of Listings.

Baryons

N's and Δ's

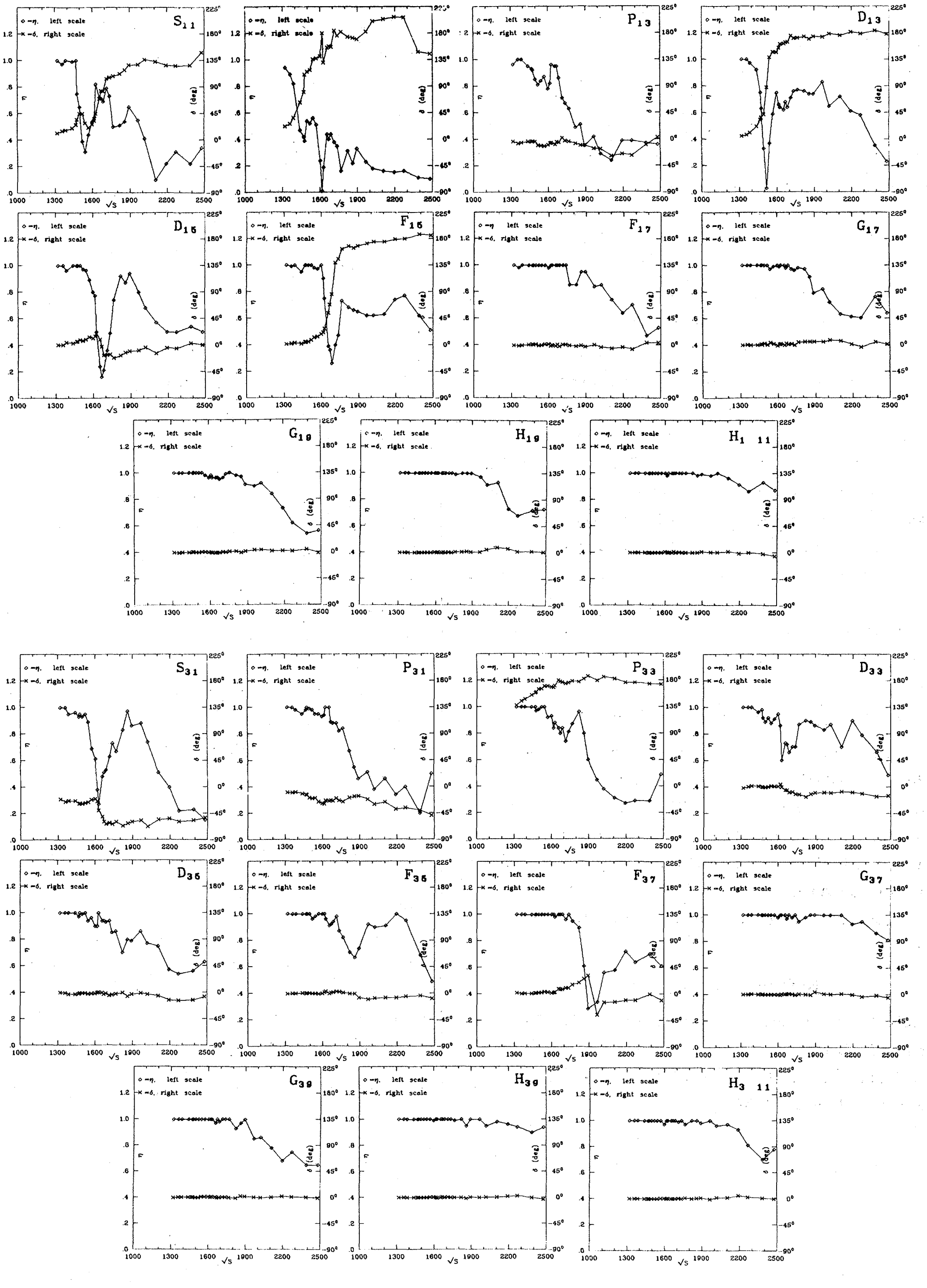

Fig. 4. δ and η versus c.m. energy (in MeV) from the πN partial-wave analysis "minimum surface" solution of AYED 70 [Phys. Letters 31B, 598(1970)]. × denotes δ (right-hand scale), ◇ denotes η (left-hand scale).

phase-shift results with an energy-dependent background and Breit-Wigner amplitudes. (This analysis appears only in the unpublished Kiev Conference report of AYED 70, not in their Physics Letter.) BAREYRE 68 uses two methods: 1) cross-section method — the energy where the total cross section is maximum; 2) speed method — the energy where the speed of variation of the amplitude in the Argand plot is maximum. CERN, as well as ALMEHED 72, quotes only one method, usually where the absorption is maximum. The Glasgow group (DAVIES 70) uses Breit-Wigner parametrization; their solutions A and B differ in the starting values of the minimization (CERN I solution was used for solution B). Only the parameters from solution A are included in the listings. For some states no parameters have been quoted by the authors.

At the beginning of the Data Card Listings for N's and Δ's, we present a table giving our evaluation 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 parameters, but only give ranges for masses and widths in order to emphasize that in some cases these parameters are quite poorly determined.

Availability of Partial-Wave Analyses and Data

All the solutions mentioned in this note, including AYED 70 and ALMEHED 72, are available on tape from the Particle Data Group. This tape is essentially an updated version of the one corresponding to the compilation of Ref. 2. In addition, the extensive input data used by ALMEHED 72 (courtesy of C. Lovelace) are also available on tape from the Particle Data Group.

References

1. Particle Data Group, Rev. Mod. Phys. 43, No. 2, Part II, S1 (1971).
2. D. J. Herndon, A. Barbaro-Galtieri, A. H. Rosenfeld, UCRL-20030 πN (Feb. 1970).

Note on N's and Δ's: Isobar Model Fits

In the figure below we show the inelastic Argand plots of Herndon 72.[1] These plots are the result of a partial-wave analysis, using the isobar model, of $\pi N \to \pi\pi N$ data in the c.m. energy range 1300-2000 MeV. The partial waves are labeled

$$LL'_{2I2J}(R),$$

where L is the incoming (πN) angular momentum, and L' is the outgoing angular momentum between the isobar R [ρ, ε (= ππ I=0, S wave), Δ] and the remaining hadron (π or N); as usual I and J are the isospin and total spin ($\vec{J} = \vec{L} + \vec{S} = \vec{L}' + \vec{S}'$) respectively. Also indicated on these Argand plots are the locations (in MeV) of known or suspected resonances from $\pi N \to \pi N$ partial-wave analyses.

Clear circular behavior is observed in many of these plots. Perhaps the most interesting among these are the $DP_{13}(\epsilon)$ and $DS_{13}(\Delta)$ partial waves. While all the D_{13} waves show evidence for the well-known N(1520), these two indicate some effect in the 1700-1800 MeV region—perhaps the long sought after $D_{13}(1700)$.

In order to estimate the inelastic coupling of the resonances indicated in these plots, we measured (with a ruler!) the diameters of "interpolated" circles. Recall that

$$A = \frac{\sqrt{xx'}}{\epsilon - i}, \quad \epsilon = \frac{2(M-E)}{\Gamma_{tot}}, \quad x = \frac{\Gamma_{el}}{\Gamma_{tot}}, \quad x' = \frac{\Gamma_{inel}}{\Gamma_{tot}};$$

thus, at resonance ($\epsilon = 0$) the circle diameter is $\sqrt{xx'}$. The amplitudes at resonance thus estimated are given in the following table. The spread in values represents our guess as to the range in resonance circles consistent with the data.

Reference

1. D. J. Herndon et al., LBL-1065 Rev. (1972), submitted to Phys. Rev.

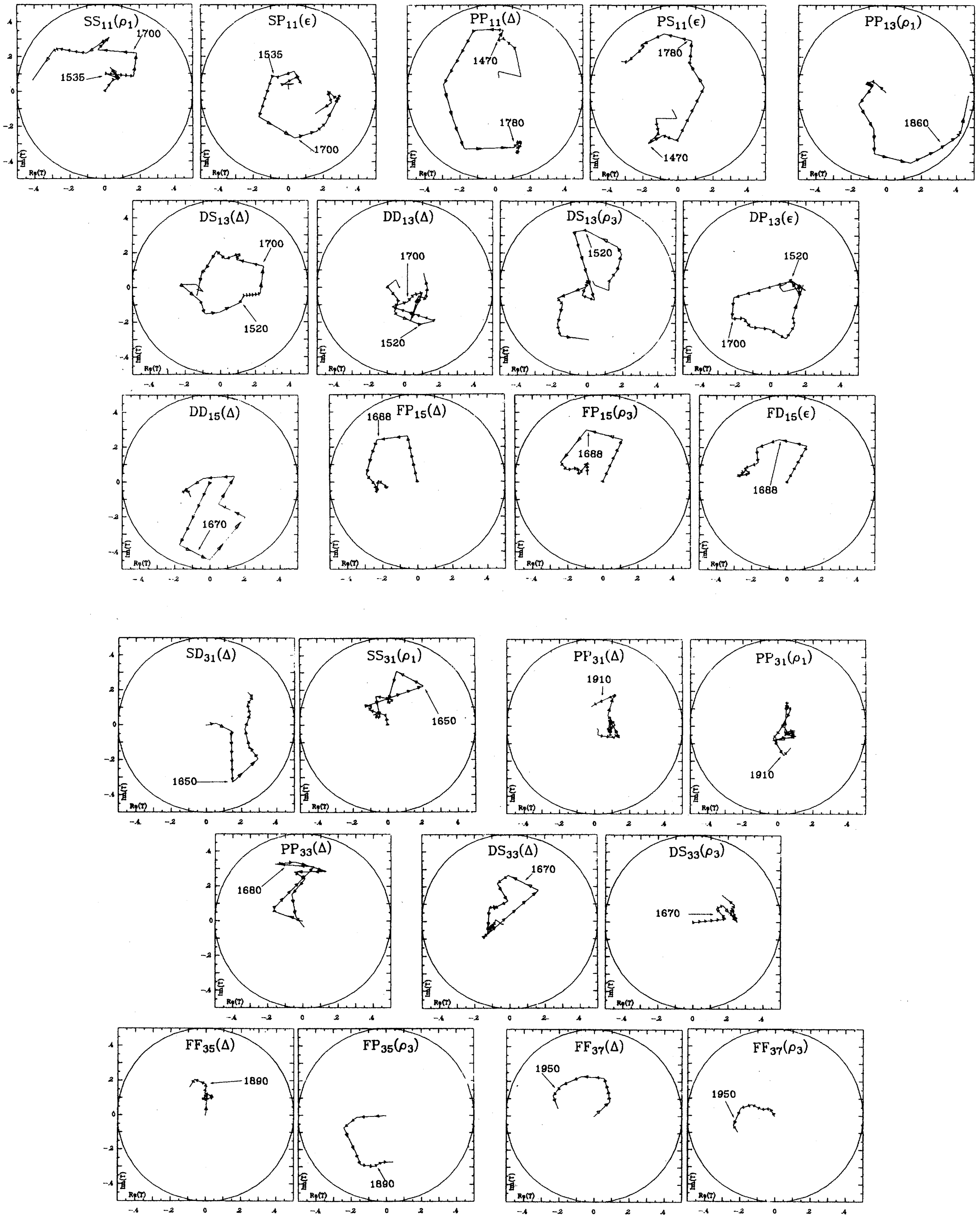

Fig. "Isobar" model Argand plots from Herndon 72. The bases of the arrowheads are 20 MeV apart. The solution covers the energy interval 1300-2000 MeV. See the mini-review text for partial-wave notation.

Amplitude at resonance, $\sqrt{xx'}$, as estimated from Argand plots of Herndon 72.[1] A dash indicates coupling cannot exist or is essentially zero.

N's	x (PDG)	πN→ρN	πN→εN	πN→πΔ	Δ's	x (PDG)	πN→ρN	πN→πΔ
$S_{11}(1535)$	.35	.07-.09	small	---	$S_{31}(1650)$	.28	.15-.21	.27-.30
$S_{11}(1700)$	.60	.20-.30	.39-.44	---	$P_{31}(1910)$	.25	.08-.20	.10-.20
$P_{11}(1470)$	.60	---	.18-.22	.35-.42	$P_{33}(1680)$[a]	~.10	---	.29-.45
$P_{11}(1780)$	.20	---	.48-.55	.43-.50	$D_{33}(1670)$	.15	small	.18-.21
$P_{13}(1860)$	.25	.43-.51	---	---	$F_{35}(1890)$	.17	.31-.35	small
$D_{13}(1520)$	.50	.31-.35	.05-.10	.28-.34[b] .11-.15[c]	$F_{37}(1950)$	.45	.19-.23	.25-.29
$D_{13}(1700)$	~.10	small	.29-.35	.09-.13[b] small[c]				
$D_{15}(1670)$	.40	---	---	.45-.49				
$F_{15}(1688)$	.60	.29-.31	.27-.28	.27-.28				

[a] Not in main Baryon Table. [b] DS_{13}. [c] DD_{13}.

Note on N's and Δ's: Photon Couplings

In this edition we start to quote results on the couplings of baryon resonances to the γN system. They can be studied in reactions like

$$\gamma N \to N^* \to \pi N,\ K\Lambda,\ K\Sigma,\ \pi\Delta, \ldots$$

A partial-wave analysis of these formation processes is the standard technique to determine the coupling strengths, $g(N^*N\gamma)$. Up to now almost all results are derived from analyses of pion-photoproduction. In the following we therefore outline the formulation of pion-photoproduction and define the conventions in which results will be quoted.

The process $\gamma N \to N^* \to \pi N$ for a specific intermediate resonance can be symbolically described as

$$\langle \pi N\,|H_\pi|\,N^*\rangle \langle N^*\,|H_\gamma|\,\gamma N\rangle\,. \qquad (1)$$

The first term is measured in strong interactions, e.g. by partial-wave analysis of πN elastic scattering. A common feature of almost all analyses of pion-photoproduction is a strong reliance on the knowledge of resonance parameters from πN phase-shift analyses. Very few attempts are made to determine new πN resonance parameters, partly because of lack of precise enough data, partly because photoproduction is complicated by the fact that the photon has spin states ±1 and can react as an isoscalar or isovector. Consequently in general, several couplings for $N^* \to \gamma N$ (2 for Δ, 4 for N) have to be determined.

Isospin Decomposition

We ignore possible isotensor components and treat the electromagnetic current as having isoscalar and isovector components only, while the final πN-state has isospin 1/2 and 3/2 components. Therefore three independent isospin amplitudes describe the 4 reactions

$$\gamma p \to \pi^+ n,\ \pi^0 p$$
$$\gamma n \to \pi^- p,\ \pi^0 n.$$

They can be chosen as the isoscalar transition to final state I=1/2, isovector transition to final state I=1/2 and isovector transition to final state I=3/2.

We define amplitudes A^Δ, A^p, and A^n such that they are naturally related to the excitation of the physical states Δ, N^{*+} and N^{*0}. Ignoring spin labels, a transition amplitude $A(\gamma N \to \pi N)$ is described by

$$\begin{aligned} A(\gamma p \to \pi N) &= C_{\pi N}^{3/2}\, A^\Delta + C_{\pi N}^{1/2}\, A^p, \\ A(\gamma n \to \pi N) &= C_{\pi N}^{3/2}\, A^\Delta + C_{\pi N}^{1/2}\, A^n, \end{aligned} \qquad (2)$$

where $C_{\pi N}^{I}$ is the C-G coefficient for the coupling of isospin I to the specific πN state under consideration.

An alternative set of amplitudes A^{V3}, A^{V1}, and A^S is used by Walker[1] with the relations

$$\begin{aligned} A^{V3} &= A^\Delta, \\ A^{V1} &= \tfrac{1}{2}(A^n - A^p), \\ A^S &= \tfrac{1}{2}(A^n + A^p), \end{aligned} \qquad (3)$$

where A^{V3} refers to isovector transition to final state I=3/2, and A^{V1} and A^S refer to isovector and isoscalar transitions to final state I=1/2 respectively.

Partial Waves

The S-matrix element for pion-photoproduction $(\gamma N_1 \to \pi N_2)$ is written in the form

$$S_{fi} = i(2\pi)^5\, \delta^4(P_f - P_i)\, W(k\omega E_1 E_2)^{-1/2} A \qquad (4)$$

where P_f and P_i are the total 4-momenta in the final and initial state, k, ω, E_1, and E_2 denote the c.m. energies of photon, pion, initial and final nucleon, and W is the total c.m. energy.

For a partial-wave analysis it is convenient to decompose A into helicity amplitudes[2]. Choosing the x-z plane as the scattering plane, the z-axis along the photon direction, and θ as the c.m. scattering angle between photon and pion, we define helicity amplitudes $A_{\mu\lambda}(W,\theta)$ (ignoring isospin labels). Here μ and λ denote the total final and initial helicities, $\mu = \lambda_\pi - \lambda_2$, $\lambda = \lambda_\gamma - \lambda_1$. Since $\lambda_\gamma = \pm 1$ and $\lambda_{1,2} = \pm 1/2$, we have a set of 8 helicity amplitudes. Because of parity conservation[2] only 4 are independent, which we choose by fixing $\lambda_\gamma = +1$. We thus consider $A_{\pm 1/2,\,1/2}$ and $A_{\pm 1/2,\,3/2}$. They are normalized such that the differential cross section is given by

$$\frac{d\sigma}{d\Omega} = \frac{1}{2}\,\frac{q}{k} \sum_{\lambda,\mu} |A_{\mu\lambda}|^2 \ .$$

Each of these is expanded in the usual way[2]

$$A_{\mu\lambda}(W,\theta) = \sum_j (2j+1)\, A^j_{\mu\lambda}(W)\, d^j_{\lambda\mu}(\theta) \qquad (5)$$

into partial wave amplitudes $A^j_{\mu\lambda}(W)$ of total angular momentum j (but mixed parity) and the Wigner rotation functions.

We define amplitudes of definite parity by

$$\begin{aligned} C_\lambda^{\ell+}(W) &= \frac{1}{\sqrt{2}}\,[A^j_{1/2\lambda}(W) + A^j_{-1/2\lambda}(W)] \\ C_\lambda^{(\ell+1)-}(W) &= \frac{1}{\sqrt{2}}\,[A^j_{1/2\lambda}(W) - A^j_{-1/2\lambda}(W)] \end{aligned} \qquad (6)$$

where λ = 1/2, 3/2. The superscripts ℓ± refer in the usual notation to states with pion orbital angular momentum ℓ and total angular momentum j = ℓ ± 1/2.

Unitarity of the S-matrix imposes a phase condition on the C amplitudes known as Watson's theorem. It states that in the elastic region the phase of each $C_\lambda^{\ell\pm}$ is equal to the scattering phase of the corresponding πN-partial wave.

Since we are interested in intermediate resonances, we approximate the energy dependence of $C_\lambda^{\ell\pm}(W)$ by a Breit-Wigner form

$$C_\lambda^{\ell\pm}(W) = s\left\{\frac{\Gamma^\lambda(N^* \to \gamma N)\,\Gamma(N^* \to \pi N)}{k \cdot q}\right\}^{1/2} \frac{W}{W^2 - m_R^2 - iW\Gamma} \qquad (7)$$

where s is the sign of the amplitude, m_R the resonance energy and k, q the c.m. momenta in the initial, final states. At resonance ($W = m_R$)

$$C_\lambda^{\ell\pm}(m_R) = s\left\{\frac{\Gamma_\gamma^\lambda\, \Gamma_\pi}{k \cdot q \cdot \Gamma^2}\right\}^{1/2} \qquad (8)$$

A dominant feature in pion-photoproduction is the Born approximation which contains the nucleon pole in the s- and u-channel and the pion pole in the t-channel. It reproduces, e.g., the experimentally observed forward peak in charged pion-photoproduction. In partial-wave analyses the sign factor s is well determined relative to the Born terms.

Introducing helicity amplitudes $A_\lambda^{j^P}$ for the decay $N^*(j^P) \to (\gamma N)_\lambda$ (where j^P labels spin and parity of the N^*), we can calculate the radiative width Γ_γ^λ[3] at resonance energy $W = m_R$

$$\Gamma_\gamma^\lambda = \frac{k^2}{\pi}\,\frac{m_N}{m_R}\,\frac{1}{2j+1}\,\left|A_\lambda^{j^P}(m_R)\right|^2 \qquad (9)$$

where m_N is the nucleon mass. Introducing this expression into eq. (8) we find

$$C_\lambda^{\ell\pm}(m_R) = \left\{ \frac{1}{(2j+1)\pi}\, \frac{k}{q}\, \frac{m_N}{m_R}\, \frac{\Gamma_\pi}{\Gamma^2} \right\}^{1/2} A_\lambda^{j^P}(m_R). \tag{10}$$

We quote results of partial-wave analyses in terms of the amplitudes $A_\lambda^{j^P}$ in units of $\mathrm{GeV}^{-1/2}$.

The total radiative width Γ_γ and the contribution $\sigma_T^{j^P}$ of the partial waves $C_\lambda^{\ell\pm}$ to the total cross section are given by

$$\Gamma_\gamma = \sum_{\lambda=-3/2}^{3/2} \Gamma_\gamma^\lambda = \frac{k^2}{\pi}\, \frac{m_N}{m_R}\, \frac{2}{2j+1} \left\{ |A_{1/2}^{j^P}|^2 + |A_{3/2}^{j^P}|^2 \right\} \tag{11}$$

$$\sigma_T^{j^P} = (C_{\pi N}^I)^2\, 2\frac{m_N}{m_R}\, \frac{\Gamma_\pi}{\Gamma^2} \left\{ |A_{1/2}^{j^P}|^2 + |A_{3/2}^{j^P}|^2 \right\} \tag{12}$$

Information in this Edition

The Baryon Table contains the branching fractions Γ_γ/Γ for 13 resonances.

Many partial-wave analyses have been performed over the last years using different methods and different data sets. R. Crawford[4] has averaged the results and tried to estimate the certainty of the parameters. His table is included in this mini-review.

The Data Card Listings contain the results of the analyses by Moorhouse and Oberlack[5] and Metcalf and Walker[6] which use the most recent data set

Photon couplings of baryon resonances as compiled by R. Crawford.[4]

State	W (GeV)	Γ (GeV)	x	λ	A_λ^p $(\mathrm{GeV})^{-\frac{1}{2}}$	A_λ^n $(\mathrm{GeV})^{-\frac{1}{2}}$	A_λ^{V1} $(\mathrm{GeV})^{-\frac{1}{2}}$	A_λ^S $(\mathrm{GeV})^{-\frac{1}{2}}$	References
P'_{11}	1.470	0.200	0.55	1/2	-.04[c]	~0	+.02	-.02	1, 5, 9, 10, 11, 12, 13
D'_{13}	1.520	0.120	0.50	1/2 3/2	-.03[b] +.17[a]	-.08[b] -.13[a]	-.03 -.15	-.06 +.02	1, 5, 9, 10, 11, 12, 13
S'_{11}	1.530	0.080	0.35	1/2	+.07[b]	-.07[b]	-.07	0	1, 5, 9, 10, 11, 12, 13
D'_{15}	1.670	0.145	0.45	1/2 3/2	+.01[d] +.02[c]	+.01[d] -.03[c]	0 -.03	+.01 -.01	1, 5, 10, 12
F'_{15}	1.690	0.125	0.60	1/2 3/2	-.01[c] +.12[b]	+.02[c] ~0	+.02 -.06	+.01 +.06	1, 5, 10, 12
S''_{11}	1.700	0.200	0.65	1/2	+.07[c]	-.07[c]	-.07	0	5
P''_{11}	1.750	0.300	0.25	1/2	+.03[d]	+.03[c]	0	+.03	5
					$A_\lambda^\Delta = A_\lambda^{V3}$ $(\mathrm{GeV})^{-\frac{1}{2}}$				
P'_{33}	1.236	0.120	1.00	1/2 3/2	-.14[a] -.24[a]				1, 5, 7, 8, 10
S_{31}	1.650	0.160	0.25	1/2	+.09[c]				5
D_{33}	1.650	0.220	0.15	1/2 3/2	+.07[c] +.02[d]				5

[a] The uncertainty of the coupling is less than 20%.
[b] The uncertainty of the coupling is less than 50%.
[c] The sign of the coupling is probably established, but its size may be uncertain by up to 100%.
[d] The sign of the coupling is not clearly established.

and cover a large energy region (up to the 4th resonance region).

Moorhouse and Oberlack quote their results in terms of the $A^{j^P}_{\lambda}$ introduced above. Metcalf and Walker follow the conventions of Walker.[1] Their amplitudes $A_{\ell\pm}$, $B_{\ell\pm}$ are related to the $A^{j^P}_{\lambda}$ by:

$$A_{\ell\pm}(m_R) = \mp\left\{\frac{1}{(2j+1)\pi}\,\frac{k}{q}\,\frac{m_N}{m_R}\,\frac{\Gamma_\pi}{\Gamma^2}\right\}^{1/2} C^{I}_{\pi N} A^{j^P}_{1/2}(m_R) \qquad (13)$$

$$B_{\ell\pm}(m_R) = \pm\left\{\frac{1}{(2j+1)\pi}\,\frac{k}{q}\,\frac{m_N}{m_R}\,\frac{\Gamma_\pi}{\Gamma^2}\right\}^{1/2} \times \left\{\frac{16}{(2j-1)(2j+3)}\right\}^{1/2} C^{I}_{\pi N} A^{j^P}_{3/2}(m_R) \qquad (14)$$

A more comprehensive collection of results and of the relationships between conventions used in different analyses will be included in the next edition.

(H. Oberlack, LBL)

References

1. R. L. Walker, Phys. Rev. 182, 1729 (1969).
2. M. Jacob and G. C. Wick, Ann. Phys. 7, 404 (1959).
3. L. A. Copley, G. Karl and E. Obryk, Nucl. Phys. B13, 303 (1969).
4. R. Crawford (Glasgow), private communication.
5. R. G. Moorhouse and H. Oberlack, Phys. Lett. 43B, 44 (1973).
   R. G. Moorhouse, H. Oberlack, and A. H. Rosenfeld, LBL-1590 (1973).
6. W. J. Metcalf and R. L. Walker, private communication of preliminary results of a phenomenological analysis of pion photoproduction data, CALTECH, Jan. 1973. Model, conventions and units as in ref. 1.
7. F. A. Berends and D. L. Weaver, Nucl. Phys. B30, 575 (1971).
8. W. Pfeil and D. Schwela, Nucl. Phys. B45, 379 (1972).
9. Y. C. Chan, N. Dombey, and R. G. Moorhouse, Phys. Rev. 163, 1632 (1967).
10. R. L. Walker, Proc. 4th Int. Symp. on Electron and Photon Interactions at High Energies, Liverpool, p. 23 (1969).
11. R. G. Moorhouse and W. A. Rankin, Nucl. Phys. B23, 181 (1970).
12. W. A. Rankin, DNPL/R15, 1.
13. A. Proia and F. Sebastiani, Let. al Nuovo Cimento 3, 483 (1970).

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CODE EVENTS QUANTITY  ERROR+  ERROR-  REFERENCE YR TECN SIGN COMMENTS  DATE
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   BACKGROUND

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                          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 --
                     --------------------------------------
              OVERALL  TOTAL≠                                             OTHER
PARTICLE LIJ   STATUS  CR.S.   PI N  ETA N  K LAM   K SIG   PI DE  GAM N CHANN.
-------------------------------------------------------------------------------

N(940)   P11   ****
N*(1470) P11   ****            ****                         ***    **     EPS N
N*(1520) D13   ****    ****    ****  *                      ***    ***    RHO N
N*(1535) S11   ****            ****  ***                           ***    RHO N
N*(1670) D15   ****    ***     ****  *      *               ***    *
N*(1688) F15   ****    ***     ****  *      *               ***    **     RHO N
N*(1700) S11   ****            ****  *      ***                    **     EPS N
N*(1700) D13   **              *            *               *             EPS N
N*(1780) P11   ***             ***   *      **              ***    *      EPS N
N*(1860) P13   ***             ***   *      **                     *      RHO N
N*(1990) F17   **              **    *      *                      *
N*(2040) D13   **              **    *      *                      *
N*(2100) S11   *               *
N*(2100) D15   *               *
N*(2175) F15   *               *            *                      *
N*(2190) G17   ***     ***     ***          *                      *
N*(2220) H19   ***     ***     ***
N*(2650)       ***     ***     *
N*(3030)       ***     ***     *
N*(3245)       *       *
N*(3690)       *       *
N*(3755)       *       *


DE(1236) P33   ****    ****    ****  F                             ****
DE(1650) S31   ****    **      ****   O                     **     **     RHO N
DE(1670) D33   ***     ***     ***     R                    **     *
DE(1690) P33   *               *        B                   **
DE(1890) F35   ***     *       ***       I                         *      RHO N
DE(1910) P31   ***     *       ***        D                 *      *      RHO N
DE(1950) F37   ****    ***     ****        D        *       **     *      RHO N
DE(1960) D35   *       *       *            E       *       *
DE(2160) P33   *               *             N
DE(2420) H311  ***     ***     ***   F
DE(2850)       ***     ***     **     O
DE(3230)       ***     ***     *       R

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****  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.

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p

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                    16  PROTON  (938, J=1/2)  I=1/2

                    SEE STABLE PARTICLE DATA CARD LISTINGS

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n

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                    17  NEUTRON  (939, J=1/2)  I=1/2

                    SEE STABLE PARTICLE DATA CARD LISTINGS

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N(1470) **P'_{11}**

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                    61  N*1/2(1470, JP=1/2+) I=1/2

                    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                    ABOVE

   THE MASS AND WIDTH ARE BEST DETERMINED FROM PHASE-SHIFT ANALYSES.  WE
   LIST PRODUCTION EXPERIMENTS SEPARATELY--SEE BELOW.
     A PRELIMINARY ENERGY DEPENDENT ANALYSIS BY AYED 72 CLAIMS THERE ARE
   TWO P11 STATES IN THE 1500 MEV REGION.  THE MOST SERIOUS DISAGREEMENT
   BETWEEN ALMEHED 72 AND AYED 72 IN FACT OCCURS IN THIS WAVE.
   SEE THE N* MINI REVIEW.

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Baryons
N(1470)

Data Card Listings
For notation, see key at front of Listings.

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                    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

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                    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
    SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                    61  N*1/2(1470) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      N*1/2(1470) INTO PI N                            139+ 938
P2      N*1/2(1470) INTO N EPSILON                       938+ 600
P3      N*1/2(1470) INTO N*3/2(1236) PI                 1236+ 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+ 770
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

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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  A AND B CORRESPOND TO THE 2 BEST SOLUTIONS. ANALYSIS IS DONE ON THREE
R1  B BODY DECAYS, ASSUMING ONLY P1, P2 AND P3 DECAYS PRESENT.
R1  7          (0.65)                   ALMEHED   72 IPWA                     2/72
    SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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          DOMINANT 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)          SAXON     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(1236) 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  O 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 INDICATICN         ROSSI     73 DBC   O 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.

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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           -.055      .028            OBERLACK  72 DPWA ' PI N PHOTO-PROD  2/73*
A1          (-.073)                     WALKER    73 DPWA   PI N PHOTO-PROD  2/73*

A2      N*1/2(1470) INTO GAM N, HELICITY=1/2 (GEV**-1/2)
A2           +.002      .025            OBERLACK  72 DPWA   PI N PHOTO-PROD  2/73*
A2          (+.058)                     WALKER    73 DPWA   PI N PHOTO-PROD  2/73*

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                              REFERENCES FOR N*1/2(1470)

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
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)

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
OBERLACK 72 PL 43B 44          H.OBERLACK,R.G.MOORHOUSE                 (LBL)
ROSSI    73 NC 13A 59          +PIAZZA,SUSINNO,+    (ROMA,FRAS,NAPL,PAVIA)IJP
    ALSO 71 LNC 2 1183         CARBONARA,FIORE,+    (NAPL,FRAS,PAVIA,ROMA)IJP
WALKER   73 TO BE PUB.         R.L.WALKER,W.J.METCALF                   (CIT)

                               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)
DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP             (GLAS+EDIN)
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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N(1470) BUMPS

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91  N*1/2(1470, JP=    ) I=1/2   PRODUCTION EXPERIMENTS

IT IS NOT CLEAR THAT THE BUMP SEEN IN PRODUCTION EXPER-
IMENTS AT LOW INVARIANT MASS CORRESPONDS TO THE P11
RESONANT STATE.  DIFFRACTION SCATTERING SEEMS TO BE THE
DOMINANT FEATURE IN THIS MASS REGION- SEE GELLERT 66,
WALKER 68 AND CLEGG 68 FOR DISCUSSION OF THIS POINT.
    WE LIST VALUES OF MASSES AND WIDTHS FROM THESE EXPERIMENTS FOR
    THE READER'S CONVENIENCE- THE LIST MAY NOT BE COMPLETE.
    THE CNTR AND SPRK EXPERIMENTS SEE A BUMP IN THE MISSING MASS
    PLOT. THE HBC EXPERIMENTS SEE ENHANCEMENTS MAINLY IN THE
    P PI PI MASS PLOT. PRODUCTION OF THIS STATE IN GAMMA-P OR
    GAMMA-D IS VERY SMALL, SEE ALBERI 68.

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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    5/68
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     (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            1460. TO 1510.               MORSE     71 HBC  +0 PI-P,  7 GEV/C     3/72
M          (1510.0)   (20.0)              MORSE     71 HBC  +  PI-P, 25 GEV/C     3/72
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       O PD  5.9GEV/C      12/72*
M          (1464.0)    (7.0)     45/45    KARSHON   72 DBC  +  PD--PD2PI 7 GEV   12/72*
M          (1440.)    (15.)               RONAT     72  HBC    PI+P TO 3PI P      2/73*
M    S   TAN 68, SHAPIRA 68, AND GAGE 72 ARE ONLY PRODUCTION EXPERIMENTS TO
M    S   SEE PPI DECAY.  HOWEVER THE EFFECT OF SHAPIRA 68, WITH MUCH IMPROVE
M    S   DATA, HAS ALMST DISAPPEARED (YEKUTIEL1 72).

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                    91  N*1/2(1470) WIDTH (MEV) (PROD. EXP.)

W           (100.)                        BELL      68 HBC     PI+- P AND PP      6/68
W    S  175 (198.)    (40.)               SHAPIRA   68 DBC                       10/69
W    S      (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             80. TO  120.                MORSE     71 HBC  +  PI-P,  7 GEV/C     3/72
W           (100.0)   (30.0)              MORSE     71 HBC  +  PI-P, 25 GEV/C     3/72
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   O PD  5.9GEV/C      12/72*
W           (124.0)   (20.0)              KARSHON   72 DBC  +  PD--PD2PI 7 GEV   12/72*
W           (100.)    (30.)               RONAT     72  HBC    PI+P TO 3PI P      2/73*

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                    91  N*1/2(1470) PARTIAL DECAY MODES (PROD. EXP.)

                                                           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(1236) PI                 1236+ 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+ 770

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Data Card Listings
For notation, see key at front of Listings.

Baryons
N(1470), N(1520)

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                    91  N*1/2(1470) BRANCHING RATIOS (PROD. EXP.)

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(1236) PI)/TOTAL         (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

R3      N*1/2(1470) INTO (N PIPI(J,I=0))/TOTAL          (P2)
R3              MAIN DECAY MODE      MORSE     71 HBC  +  PI-P 7,25 GEV/C   3/72

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                      REFERENCES FOR N*1/2(1470) (PROD. EXP.)

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 288 195        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
MORSE    71 PR D4 133         +OH,WALKER,CARROLL,LYNCH +       (WISC+TNTO)IJ
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)
KARSHON  72 NP B37 371        +YEKUTIELI,YAFFE,SHAPIRA,RONAT,+     (REHO) I
RONAT    72 NP B38 20     40. +EISENBERG,LYONS,SHAPIRA,TOAFF+      (REHO)
YEKUTIEL 72 NP B40 77         YEKUTIELI,YAFFE,SHAPIRA,RONAT +      (REHO)

                              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)
CLEGG    68  PREPRINT         A B CLEGG                            (LANC)
WALKER   68 PRL 20 133        +THOMPSON,ROBERTSON,OH,LEE,HARTUNG,+ (WISC)

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N(1520) 62 N*1/2(1520, JP=3/2-) I=1/2 **D'_{13}**

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                FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                PRECEDING N*1/2(1470).

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                62  N*1/2(1520) MASS (MEV)

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

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                62  N*1/2(1520) WIDTH (MEV)

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
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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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(1236) PI               1236+ 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+ 600
P8      N*1/2(1520) INTO N RHO                         938+ 770
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

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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      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(1236) PI, IN BOTH
R1   S AND D WAVES.
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R2      N*1/2(1520) INTO (N*3/2(1236) 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(1236) 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

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

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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            -.026     .015          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A1           (-.007)                  WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

A2      N*1/2(1520) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2            +.194     .031          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A2           (+.176)                  WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

A3      N*1/2(1520) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3            -.085     .014          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A3           (-.043)                  WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

A4      N*1/2(1520) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4            -.124     .013          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A4           (+.116)                  WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

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                          REFERENCES FOR N*1/2(1520)

        SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.

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,LOIC)
OLSSON   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
OBERLACK 72 PL 43B 44         H.OBERLACK,R.G.MOORHOUSE                (LBL)
WALKER   73 TO BE PUB.        R.L.WALKER,W.J.METCALF                  (CIT)

                              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)
AYED     70 PL 31B 598        +BAREYRE+VILLET                        (SACLAY)

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N(1535) S'_{11}

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63   N*1/2(1535, JP=1/2-) I=1/2

     FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
     PRECEDING N*1/2(1470).

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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

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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
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
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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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+ 600
P5       N*1/2(1535) INTO N*3/2(1236) PI               1236+ 139
P6       N*1/2(1535) INTO N RHO                         938+ 770
P7       N*1/2(1535) INTO N GAMMA                       938+   0
P8       N*1/2(1535) INTO GAM P, HELICITY=1/2             0+ 938
P9       N*1/2(1535) INTO GAM N, HELICITY=1/2             0+ 939

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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

R2       N*1/2(1535) INTO (N ETA)/TOTAL                       (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)

R3       N*1/2(1535) INTO (N*3/2(1236) 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 N GAMMA                             (P7)
R6              0.004     0.001         DEANS      72 MPWA    N ETA PHOTOPROD.  1/73*

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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            +.053      .020           OBERLACK   72 DPWA    PI N PHOTO-PROD   2/73*
A1           (+.063)                    WALKER     73 DPWA    PI N PHOTO-PROD   2/73*

A2       N*1/2(1535) INTO GAM N, HELICITY=1/2 (GEV**-1/2)
A2            -.048      .021           OBERLACK   72 DPWA    PI N PHOTO-PROD   2/73*
A2           (-.050)                    WALKER     73 DPWA    PI N PHOTO-PROD   2/73*

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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)
OBERLACK 72 PL 43B 44          H.OBERLACK,R.G.MOORHOUSE                (LBL)
WALKER   73 TO BE PUB.         R.L.WALKER,W.J.METCALF                  (CIT)

                               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)
BLOOM    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)
          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(1520) BUMPS

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8   N*1/2(1520, JP=    ) I=1/2   PRODUCTION EXPERIMENTS

    THIS INFORMATION REFERS TO EITHER THE D13 OR THE S11
    STATE SEEN AT THIS MASS
  FOR SPIN-PARITY ANALYSIS OF THIS MASS REGION, SEE JOHNSTAD 72.

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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 CNTR    P P AT 24 GEV    10/71
M           1512.0      2.0             ELLIS     71 CNTR    MMS PP 3.7 GEV/C 10/71
M           1501.0      5.7             EDELSTEIN 72 MMS  +  PP 6 TO 30 GEV    1/73*
M           . . . . . . . . . . .
M    AVG    1510.8      3.4       AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
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*

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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 CNTR    P P AT 24 GEV    10/71
W             88.0      2.0             ELLIS     71 CNTR    MMS PP 3.7 GEV/C 10/71
W            140.0     43.0             EDELSTEIN 72 MMS  +  PP 6 TO 30 GEV    1/73*
W           . . . . . . . . . . .
W    AVG      88.1      2.0       AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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(1236) PI               1236+ 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+ 770

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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(1236) PI)/(N PI PI)      (P2)/(P3)
R4              0.00      0.09          A-BORELLI 67 HBC                        9/66
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Data Card Listings

For notation, see key at front of Listings.

Baryons

N(1535), N(1670), N(1688)

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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(1236))           (P1)/(P2)
R7           (0.42) OR LESS          LEE       67 HBC      PI-P 3.6  GEV/C   11/67

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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)

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

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N(1670) D'_{15}

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                    64  N*1/2(1670, JP=5/2-) I=1/2

                    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                    PRECEDING N*1/2(1470).

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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

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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
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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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(1236) PI                 1236+ 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

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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
       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             (0.01) OR LESS           TRIPP     67 RVUE                      8/67
R3   B         (0.00) OR LESS           RUSH      68 MPWA    T POLE + RESON.   8/69
R3   B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING
R3             (0.00) OR LESS  CL=.63   WAGNER    71 IPWA    PI-P TO K LAMB    1/71

R4      N*1/2(1670) INTO (N*3/2(1236) 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

    SEE NOTE 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             +.011      .012          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A1             (+.010)                  WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

A2      N*1/2(1670) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2             +.021      .020          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A2             (+.039)                  WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

A3      N*1/2(1670) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3             +.010      .040          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A3             (.00)                    WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

A4      N*1/2(1670) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4             -.035      .014          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A4             (.00)                    WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

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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
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)
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
OBERLACK 72 PL 43B 44             H.OBERLACK,R.G.MOORHOUSE                 (LBL)
WALKER   73 TO BE PUB.            R.L.WALKER,W.J.METCALF                   (CIT)

                                  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,OXF)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)

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N(1688) F'_{15}

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                    65  N*1/2(1688, JP=5/2+) T=1/2

                    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                    PRECEDING N*1/2(1470).

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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)                     DONNACH1  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

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                    65  N*1/2(1688) WIDTH (MEV)

W    1      (110.0)                     BAREYRE   68 RVUE                     11/67
W    3      (177.0)                     DONNACH1  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
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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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(1236) PI                 1236+ 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+ 600
P11     N*1/2(1688) INTO N RHO                           938+ 770

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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)                  DONNACH1  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
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

    MORE INFORMATION  ON THE INELASTIC DECAY MODES OF THE 1690 MEV
    BUMP, AS SEEN IN PRODUCTION EXPERIMENTS, MAY BE FOUND BELOW

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
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R3      N*1/2(1688) INTO (N ETA)/(PI N)                   (P2)/(P1)
R3            (0.027)OR LESS          HEUSCH     66 RVUE +  PI0, ETA PHOTO     9/66

R4      N*1/2(1688) INTO (LAMBDA K)/TOTAL                 (P3)
R4            (0.00) 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(1236) 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

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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             -.008      .004          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A1            (+.009)                   WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

A2      N*1/2(1688) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2             +.100      .012          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A2            (+.135)                   WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

A3      N*1/2(1688) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3             +.017      .014          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A3             (.00)                    WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

A4      N*1/2(1688) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4             -.005      .018          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A4             (.00)                    WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

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                              REFERENCES FOR N*1/2(1688)

          SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.

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
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)
DUKE     68 PR 166 1448       +JONES,KEMP,MURPHY,THRESHER, +   (RHEL,OXF)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 253        +CASHMORE+..+HERNDON+..             (SLAC+LRL)
WAGNER   71 NP B25 411        F WAGNER, C LOVELACE                    (CERN)

ALMEHED  72 NP B40 157        +LOVELACE                        (LUND,RUTG)IJP
OBERLACK 72 PL 43B 44         H.OBERLACK,R.G.MOORHOUSE                 (LBL)
WALKER   73 TO BE PUB.        R.L.WALKER,W.J.METCALF                   (CIT)

                              PAPERS NOT REFERRED TO IN DATA CARDS.

CROUCH   65 DESY CONF 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)

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N(1700)

66 N*1/2(1700, JP=1/2-) I=1/2 S''_{11}

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                       FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                       PRECEDING N*1/2(1470).

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                       66  N*1/2(1700) 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    1     (1710.0)                       BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M    1            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

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                   66  N*1/2(1700) 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
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                   66  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 N ETA                                939+ 548
P3      N*1/2(1700) INTO LAMBDA K                            1115+ 497
P4      N*1/2(1700) INTO N GAMMA                              938+   0
P5      N*1/2(1700) INTO GAM P, HELICITY=1/2                    0+ 938
P6      N*1/2(1700) INTO GAM N, HELICITY=1/2                    0+ 939
P7      N*1/2(1700) INTO N PI PI                              938+ 139+ 139
P8      N*1/2(1700) INTO N EPSILON                            938+ 600
P9      N*1/2(1700) INTO N RHO                                938+ 770

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                   66  N*1/2(1700) BRANCHING RATIOS

R1      N*1/2(1700) 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


R2      N*1/2(1700) INTO (LAMBDA K)*(PI N)/TOTAL**2        (P3*P1)
R2             0.039    0.019           ORITO     69 RVUE                        8/69
R2   A        (0.043)OR 0.054           WAGNER    71 IPWA    PI-P TO K LAMB      1/71

R3      N*1/2(1700) 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(1700) 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(1700) FROM N GAMMA TO LAMBDA K               SQRT(P3*P4)
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            (0.006)                   DEANS     72 MPWA                       1/73*
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                   66  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             +.066      .042          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A1            (+.011)                   WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

A2      N*1/2(1700) INTO GAM N, HELICITY=1/2 (GEV**-1/2)
A2             -.072      .066          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A2            (-.015)                   WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

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                              REFERENCES FOR N*1/2(1700)

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,WEILNBOECK                      (MPIM)

WAGNER   71 NP B25 411        F WAGNER, C LOVELACE                    (CERN)

ALMEHED  72 NP B40 157        +LOVELACE                        (LUND,RUTG)IJP
DEANS    72 PN 3 217          +JACOBS, LYONS, HICKS   (U S FL TAMPA+CARN)
OBERLACK 72 PL 43B 44         H.OBERLACK,R.G.MOORHOUSE                 (LBL)
WALKER   73 TO BE PUB.        R.L.WALKER,W.J.METCALF                   (CIT)

                              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)

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Data Card Listings

For notation, see key at front of Listings.

Baryons
N(1700)

N(1700) **D''_{13}**

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18  N*1/2(1700, JP=3/2-) I=1/2

→      FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
       PRECEDING N*1/2(1470).
 A NEW, PRELIMINARY ENERGY DEPENDENT ANALYSIS BY AYED 72 INDICATES THE
PRESENCE OF THIS STATE.  IN ADDITION AN ISOBAR MODEL ANALYSIS BY
HERNDON 72 SHOWS EVIDENCE FOR THIS STATE IN THE SIGMA N AND DELTA PI
CHANNELS.  SEE THE N* MINI REVIEW.

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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.

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                  18  N*1/2(1700) WIDTH (MEV)

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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 N GAMMA                           938+   0

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                  18  N*1/2(1700) BRANCHING RATIOS

R1      N*1/2(1700) FROM N GAMMA TO LAMBDA K              SQRT(P2*P3)
R1            (0.008)                DEANS      72 MPWA                       1/73*

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                                REFERENCES FOR N*1/2(1700)

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 PN 3 217            +JACOBS, LYONS, HICKS   (U S FL TAMPA+CARN)

                                PAPERS NOT REFERRED TO IN DATA CARDS.

AYED     72 BATAVIA CONF        R AYED,P BAREYRE, Y LEMOIGNE         (SACL)
HERNDON  72 BATAVIA CONF        +...ROSENFELD...+CASHMORE+...    (LBL,SLAC)

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N(1700) BUMPS

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20  N*1/2(1700, JP=    ) I=1/2   PRODUCTION EXPERIMENTS

   PARTIAL WAVE ANALYSIS REQUIRES AT LEAST FOUR I=1/2 STATES IN THE 1670 T
   1780 REGION (D15, F15, S11, P11) AND AT LEAST ONE I=3/2 STATE (D33).
   OBVIOUSLY,DIFFERENT EXPERIMENTS ARE SEEING DIFFERENT STATES AND OFTEN I
   IS NOT CLEAR WHAT ISOSPIN STATE IS BEING OBSERVED.  NO EFFORT WAS MADE
   TO SEPARATE THESE EXPERIMENTS ACCORDING TO JP, SINCE NONE OF THE
   REPORTED JP IS FIRMLY ESTABLISHED.  WE LIST ALL THE INFORMATION HERE,
   BUT WE HAVE NOT USED IT IN THE BARYON TABLE.
      FOR SPIN-PARITY ANALYSIS OF THIS MASS REGION, SEE JOHNSTAD 72 AND
   LAMSA 72.

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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   A    (1667.0)    (5.0)             BENVENUTI 69 DBC   0 PI-D 2.26 GEV     5/70
M   B  190(1693.)   (15.)              RHODE     69 HBC     PP 22 GEV/C      10/69
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        (1694.0)    (8.0)             AMALDI    71 CNTR    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   2    (1660.)  (15.                 OH        72 DBC   0 PI-N TO PI-PI-P   2/73*
M        (1720.)    (15.)              RONAT     72  HBC    PI+P TO 3PI P     2/73*
M  C   ANALYSIS GIVES JP = 5/2+
M   2  DETERMINE J=5/2,F15 PROBABLE                                           2/73*
M   B  JP IS PROBABLY 5/2+
M   1      IJP CONSISTENT WITH S11(1700) OR P11(1780) IN FORMATION
M   A        J CONSISTENT WITH 5/2 OR 7/2

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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 CNTR    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*
      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(1236) PI                   1236+ 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(1236)++ PI-               1236+ 139
P7      N*1/2(1700) INTO N ETA                             939+ 548
P8      N*1/2(1700) INTO LAMBDA K                         1115+ 497

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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(1236))           (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

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(1236) 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)

R8      N*1/2(1700) INTO (N*(1236)++ 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(1236)++ 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           . . . . . . . . . .
R8   AVG       0.66      0.10     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

R9      N*1/2(1700) INTO (SIG K)/(LAMB K)                  PROD. EXP.
R9          LESS THAN    .20         COOPER    70 HBC  +  PI+P, 5.5 GEV/C   2/71

        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                         REFERENCES FOR N*1/2(1700) (PROD. EXP.)

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)
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Baryons
N(1700), N(1780), N(1860)

Data Card Listings
For notation, see key at front of Listings.

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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,LOIC) 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     40.     +EISENBERG,LYONS,SHAPIRA,TOAFF+      (REHO)

                                   PAPERS NOT REFERRED TO IN DATA CARDS.

MERLO     66 P ROY SOC 289 489 J P MERLO, G VALLADAS                (SACLAY)

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N(1780)

P''_{11}

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                 14  N*1/2(1780, JP=1/2+) I=1/2

                 FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                 PRECEDING N*1/2(1470).

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                 14  N*1/2(1780) 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

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                 14  N*1/2(1780) 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
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                 14  N*1/2(1780) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1        N*1/2(1780) INTO PI N                        139+ 938
P2        N*1/2(1780) INTO LAMBDA K                   1115+ 497
P3        N*1/2(1780) INTO N ETA                       939+ 548
P4        N*1/2(1780) INTO N GAMMA                     938+   0
P5        N*1/2(1780) INTO GAM P, HELICITY=1/2           0+ 938
P6        N*1/2(1780) INTO GAM N, HELICITY=1/2           0+ 939
P7        N*1/2(1780) INTO N PI PI                     938+ 139+ 139
P8        N*1/2(1780) INTO N EPSILON                   938+ 600
P9        N*1/2(1780) INTO N RHO                       938+ 770

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                 14  N*1/2(1780) BRANCHING RATIOS

R1        N*1/2(1780) 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

R2        N*1/2(1780) INTO (LAMBDA K)*(PI N)/TOTAL**2        (P2*P1)
R2              0.004    0.003       ORITO     69 RVUE                      8/69
R2  A          (0.025)OR 0.043       WAGNER    71 IPWA    PI-P TO K LAMB    1/71

R3        N*1/2(1780) 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(1780) 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(1780) FROM N GAMMA TO LAMBDA K               SQRT(P2*P4)
R5             (0.0027)              ORITO2    69 CNTR    K LAM PHOTOPRO   10/71
R5             (0.0088)              SCHORSCH  70 DPWA    K LAM PHOTOPRO.  10/71
R5             (0.0104)              DEANS     72 MPWA                      1/73*

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                 14  N*1/2(1780) PHOTON DECAY AMPL(GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*1/2(1780) INTO GAM P, HELICITY=1/2 (GEV**-1/2)
A1            +.026     .028        OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A1           (-.061)                WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

A2      N*1/2(1780) INTO GAM N, HELICITY=1/2 (GEV**-1/2)
A2            +.027     .022        OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A2           (+.052)                WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

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                                  REFERENCES FOR N*1/2(1780)

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 PN 3 217              +JACOBS, LYONS, HICKS   (U S FL TAMPA+CARN)
OBERLACK 72 PL 43B 44             H.OBERLACK,R.G.MOORHOUSE              (LBL)
WALKER   73 TO BE PUB.            R.L.WALKER,W.J.METCALF                (CIT)

                                  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)

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N(1860)

P_{13}

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                 15  N*1/2(1860, JP=3/2+) I=1/2

                 FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                 PRECEDING N*1/2(1470).

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                 15  N*1/2(1860) 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

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                 15  N*1/2(1860) 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
             SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                 15  N*1/2(1860) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1        N*1/2(1860) INTO PI N                        139+ 938
P2        N*1/2(1860) INTO LAMBDA K                   1115+ 497
P3        N*1/2(1860) INTO N ETA                       939+ 548
P4        N*1/2(1860) INTO N PI PI                     938+ 139+ 139
P5        N*1/2(1860) INTO N GAMMA                     938+   0
P6        N*1/2(1860) INTO N RHO                       938+ 770

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                 15  N*1/2(1860) BRANCHING RATIOS

R1        N*1/2(1860) 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

R2        N*1/2(1860) 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(1860) 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(1860) INTO (LAMBDA K)*(PI N)/TOTAL**2        (P2*P1)
R4  A          (0.015)               WAGNER    71 IPWA    PI-P TO K LAMB    1/71

R5        N*1/2(1860) FROM N GAMMA TO LAMBDA K               SQRT(P2*P5)
R5             (0.008)               DEANS     72 MPWA                      1/73*

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Data Card Listings
For notation, see key at front of Listings.

Baryons
N(1860), N(1990), N(2040), N(2100)

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                                   REFERENCES FOR N*1/2(1860)

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)
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 PN 3 217               +JACOBS, LYONS, HICKS   (U S FL TAMPA+CARN)

                                   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)

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N(1990) F_{17}

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                         17  N*1/2(1990, JP=7/2+) I=1/2

                         A NEW, PRELIMINARY ENERGY DEPENDENT ANALYSIS BY
                         AYED 72 NOW FINDS THIS STATE.  SEE THE N* MINI REVIEW.

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                         17  N*1/2(1990) MASS (MEV)

M   3     (1983.0)                    DONNACH1  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

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                         17  N*1/2(1990) WIDTH (MEV)

W   3      (225.0)                    DONNACH1  68 RVUE                      8/69
W   3      (250.)                     KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W   7      (200.)                     ALMEHED   72 IPWA                      2/72

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                         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 N GAMMA                            938+   0

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                         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

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 N GAMMA TO LAMBDA K               SQRT(P4*P5)
R3          (0.003)                   DEANS     72 MPWA                      1/73*

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                                   REFERENCES FOR N*1/2(1990)

DONNACH1 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 PN 3 217               +JACOBS, LYONS, HICKS   (U S FL TAMPA+CARN)

                                   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)
AYED     72 BATAVIA CONF           R AYED,P BAREYRE, Y LEMOIGNE          (SACL)

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N(2040) D'''_{13}

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                         16  N*1/2(2040, JP=3/2-) I=1/2

                         FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                         PRECEDING N*1/2(1470).

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                         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

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                         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
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                         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 N GAMMA                            938+   0

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                         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

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 N GAMMA TO LAMBDA K               SQRT(P4*P5)
R3          (0.007)                   DEANS     72 MPWA                      1/73*

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                                   REFERENCES FOR N*1/2(2040)

DONNACH1 68 PL 26B 161             A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 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 PN 3 217               +JACOBS, LYONS, HICKS   (U S FL TAMPA+CARN)

                                   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)

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N(2100) S'''_{11}

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                         04  N*1/2(2100, JP=1/2-) I=1/2

                           A NEW, PRELIMINARY ENERGY DEPENDENT ANALYSIS BY
                         AYED 72 NOW FINDS EVIDENCE FOR THIS RESONANCE AT
                         ABOUT 2200 MEV.  SEE THE N* MINI REVIEW.

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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

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                         04  N*1/2(2100) WIDTH (MEV)

W   7      (200.)                     ALMEHED   72 IPWA                      2/72

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                         04  N*1/2(2100) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      N*1/2(2100) INTO PI N                               139+ 938

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Baryons
N(2100), N(2175), N(2190)

Data Card Listings
For notation, see key at front of Listings.

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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

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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

                             PAPERS NOT REFERRED TO IN DATA CARDS.

AYED     72 BATAVIA CONF      R AYED,P BAREYRE, Y LEMOIGNE         (SACL)

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N(2100)

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                 05  N*1/2(2100, JP=5/2-) I=1/2
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D''_{15}

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                   A NEW, PRELIMINARY ENERGY DEPENDENT ANALYSIS BY
                 AYED 72 NOW FINDS EVIDENCE FOR THIS RESONANCE AT
                 ABOUT 2055 MEV.  SEE THE N* MINI REVIEW.

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                 05  N*1/2(2100) MASS (MEV)

M   7     (2100.)                  ALMEHED   72 IPWA                  2/72

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                 05  N*1/2(2100) WIDTH (MEV)

W   7       (150.)                 ALMEHED   72 IPWA                  2/72

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                 05  N*1/2(2100) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     N*1/2(2100) INTO PI N                          139+ 938

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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

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                             REFERENCES FOR N*1/2(2100)

ALMEHED  72 NP B40 157        +LOVELACE                        (LUND,RUTG)IJP

                             PAPERS NOT REFERRED TO IN DATA CARDS.

AYED     72 BATAVIA CONF      R AYED,P BAREYRE, Y LEMOIGNE         (SACL)

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N(2175)

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                 06  N*1/2(2175, JP=5/2+) I=1/2
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F''_{15}

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                   SEE THE NOTE ON N'S AND DELTAS PRECEDING THE
                 BARYON DATA CARD LISTINGS.

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                 06  N*1/2(2175) MASS (MEV)

M   7     (2175.)                  ALMEHED   72 IPWA                  2/72

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                 06  N*1/2(2175) WIDTH (MEV)

W   7       (150.)                 ALMEHED   72 IPWA                  2/72

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                 06  N*1/2(2175) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     N*1/2(2175) INTO PI N                          139+ 938
P2     N*1/2(2175) INTO LAMBDA K                     1115+ 497
P3     N*1/2(2175) INTO L GAMMA                       938+   0

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                 06  N*1/2(2175) BRANCHING RATIOS

R1     N*1/2(2175) INTO (PI N)/TOTAL                       (P1)
R1  7        (0.25)                ALMEHED   72 IPWA                  2/72

R2     N*1/2(2175) FROM N GAMMA TO LAMBDA K            SQRT(P2*P3)
R2           (0.002)               DEANS     72 MPWA                  1/73*

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                             REFERENCES FOR N*1/2(2175)

ALMEHED  72 NP B40 157        ,LOVELACE                              (RUTG)IJP
DEANS    72 PN 3 217          +JACOBS, LYONS, HICKS   (U S FL TAMPA+CARN)

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N(2190)

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                 71  N*1/2(2190, JP=7/2-) I=1/2
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G_{17}

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                 ROYCHOUDHURY 71 FIND SOME INDICATION OF P11 AND F17 IN
                 THIS REGION.BRANSDEN 71 ALSO FIND P11,F15,AND G19 RESO-
                 NANT NEAR THIS MASS.

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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)                DONNACH1  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*

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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
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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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+1765
P3     N*1/2(2190) INTO N PI PI                       938+ 139+ 139
P4     N*1/2(2190) INTO N GAMMA                       938+   0

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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  0 PI-P BKWD ELSTC   2/73*

R2     N*1/2(2190) FROM N GAMMA TO LAMBDA K            SQRT(P2*P4)
R2           (0.016)               DEANS     72 MPWA                      1/73*

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                             REFERENCES FOR N*1/2(2190)

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 PN 3 217          +JACOBS, LYONS, HICKS   (U S FL TAMPA+CARN)
OTT      72 PL 42B 133        +TRISCHUK,VAVRA,RICHARDS,+ (MCGI,STLO,IOWA)IJP-
    ALSO 72 MCGILL THESIS    J.VAVRA                               (MCGI) JP

                             PAPERS NOT REFERRED TO IN DATA CARDS.

AYED     70 PL 31B 598        +BAREYRE,VILLET                      (SACLAY)

                QUANTUM NUMBER DETERMINATIONS 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,OXF)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)

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N(2220) H_{19}

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90  N*1/2(2220, JP=9/2+) I=1/2

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*1/2(1470).

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                 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

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                 90  N*1/2(2220) WIDTH (MEV)

W   6     (258.0)                   AYED      70 IPWA                     1/71
W         (329.0)                   HULL      70 MPWA   SMALL ANGLE P.I-P 1/71

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                 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

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                 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

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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)

                            PAPERS NOT REFERED TO IN DATA CARDS

AYED     70 PL 31B 598         +BAREYRE,VILLET                     (SACLAY)

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N(2650) BUMPS

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72  N*1/2(2650, JP=    -) 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).

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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           CITRON    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 RATIOS (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        CITRON    66 CNTR   TOTAL CROSS-SEC. 11/67
R1  B        (0.30)                 BARGER    67 RVUE   USES KORMANYOS67 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        (0.24)                 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
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                            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 CROSS SECTIONS, 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(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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                 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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Comments on the Mass and Width of Δ(1236)

In our last edition, we presented an exhaustive discussion of the relative "uniqueness" of the pole position. On the basis of that study we have entered the pole position in both the Table and the Data Card Listings. We remind the reader of our conclusions.

1) Over a reasonable energy interval on the real axis, all parametrizations of the amplitude are equally good provided:

a) they fit the data,

b) they are unitary and have sensible "cut" features (e.g., $\delta_\ell \propto q^{2\ell+1}$).

2) For good fits to the same data, the resonance mass and width on the real axis depend upon the parametrization used (background + BW, different BW's, etc.). Indeed, we found that the fitted mass parameter ranged from 1230 to 1235 MeV, and the width from 109 to 124 MeV. Clearly, it is meaningless for us to average masses and widths corresponding to either different parametrizations or significantly different sets of data.

3) For good fits to the same data, the pole position is essentially independent of the parametrization.

Δ(1236) **P'_{33}**

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33   N*3/2(1236, JP=3/2+) I=3/2

      CARTER 71 REPORT NEW PRECISE CROSS SECTION MEASURE-
      MENTS FOR PI+P,PI-P AND CHARGE EXCHANGE. THEIR ANALYSIS
      COMBINES TOTAL CROSS SECTION DATA WITH THE PHASE SHIFTS
      OF DONNACHIE 68 (USED FOR THE BACKGROUND UNDER THE P33)
THE CHARGE EXCHANGE DATA WERE NOT USED.
   OLSON 65 HAS DONE A SIMILAR ANALYSIS ON OLDER DATA, USING ROPER 65
PHASE SHIFTS WITH A FREE OVERALL NORMALIZATION.
   SEE THE ACCOMPANYING NOTE, 'COMMENTS ON THE MASS AND WIDTH OF
DELTA(1236)'.

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                      33   N*3/2(1236)  MASS (MEV)

M          (1234.)                      ROPER     65 DPWA ++0 PHASE SHIFT AN.
M          (1235.)                      ALMEHED   72 IPWA                      2/72
M++         1236.0     0.55             OLSSON    65 RVUE ++ TOTAL-SIGMA DATA
M++         1230.0     0.6              CARTER    71 MPWA ++ PI+P SIG. TOTAL   1/71
M++         . . . . . . . . .
M++ AVERAGE MEANINGLESS (SCALE FACTOR = 7.4)

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(1236) WIDTH (MEV)

W           (120.)                      ROPER     65 DPWA ++0 PHASE SHIFT AN.
W           (129.)                      ALMEHED   72 IPWA                      2/72
W++          120.0     2.0              OLSSON    65 RVUE ++
W++          112.8     3.0              CARTER    71 MPWA ++ PI+P SIG TOT.     1/71
W++         . . . . . . . . .
W++ AVERAGE MEANINGLESS (SCALE FACTOR = 2.0)

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*3/2(1236) REAL PART OF POLE POSITION(MEV)

REE        (1211.)                      BALL      72                          2/73*
REE   P     1211.6     0.7              PDG       72          FIT DELTA 33    2/73*
REE   P  ERROR EST. FROM FITS WITH SOMEWHAT VARYING ASSUMPTIONS

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                      33   N*3/2(1236) IMAG PART OF POLE POSITION(MEV)

IME   P       49.5     1.8              PDG       72          FIT DELTA 33    2/73*
IME          (50.)                      BALL      72                          2/73*

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                      33   (N*0) - (N*++) MASS DIFFERENCE (MEV)

D   R        (0.45)   (0.85)            OLSSON    65 RVUE
D   R        (2.9)    (0.85)            CARTER    71 MPWA     PI+- P SIG.TOT.  2/71
D   R      REDUNDANT WITH DATA IN MASS LISTING.

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                      33   N*3/2(1236) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     N*3/2(1236) INTO N PI                                938+ 139
P2     N*3/2(1236) INTO N GAMMA                             938+   0
P3     N*3/2(1236) INTO N PI PI                             938+ 139+ 139
P4     N*3/2(1236) INTO GAM NUCLEON, HELICITY=1/2             0+ 938
P5     N*3/2(1236) INTO GAM NUCLEON, HELICITY=3/2             0+ 938

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                      33   N*3/2(1236) BRANCHING RATIOS

R1     N*3/2(1236) 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  AVG       0.542    0.016    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2     N*3/2(1236)0 INTO (N PI)/TOTAL                    (P1)
R2           (0.99)                     CARTER    71 MPWA  0 PI-P FORM. EXPER  1/71

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Data Card Listings

For notation, see key at front of Listings.

Baryons

Δ(1236), Δ(1650), Δ(1670)

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                 33  N*3/2(1236) PHOTON DECAY AMPL(GEV**-1/2)

       FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
     REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*3/2(1236) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)
A1           -.142      .006          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A1          (-.139)                   WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

A2      N*3/2(1236) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)
A2           -.259      .016          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A2          (-.253)                   WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

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                             REFERENCES FOR N*3/2(1236)

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.

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,BOISE,UCI)
OBERLACK  72 PL 43B 44          H.OBERLACK,R.G.MOORHOUSE             (LBL)
PDG       72 PL 39B 103
WALKER    73 TO BE PUB.         R.L.WALKER,W.J.METCALF               (CIT)

                                PAPERS NOT REFERRED TO IN DATA CARDS.

DONNACHI  68 PL 26B 161         DONNACHIE,LOVELACE,KIRSOPP          (CERN)

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Δ(1236) BUMPS

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                 81  N*3/2(1236, JP=3/2+)  I=3/2  PRODUCTION EXPERIMENTS

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                 81  N*3/2(1236) 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++        (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++         . . . . . . . . . .
M++ AVG     1228.4      2.9      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7)
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(1236) 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           . . . . . . . . . .
W    AVG     111.6      4.7      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
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 DBCC    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++         . . . . . . . . . .
W++ AVG      118.8      4.7      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
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(1236) (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,MONARI++     (SABRE COLL)
ELLIS    71 PRL 27 442          +MAGLICH,NOREM,SANNES,SILVERMAN     (RUTG)
COLTON   72 PR D6 95            E COLTON, A KIRSCHBAUM               (LBL)

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Δ(1650) S31

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         82  N*3/2(1650, JP=1/2-) I=3/2

         FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
         PRECEDING N*1/2(1470).

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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)                   DONNACH1  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

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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      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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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(1236) PI               1236+ 139
P5      N*3/2(1650) INTO N RHO                         938+ 770

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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

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                 82  N*3/2(1650) PHOTON 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           +.090      .076          OBERLACK  72 DPWA    PI N PHOTO-PROD   2/73*
A1          (+.112)                   WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

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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
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)

ALMEHED   72 NP B40 157         +LOVELACE                      (LUND,RUTG)IJP
OBERLACK  72 PL 43B 44          H.OBERLACK,R.G.MOORHOUSE               (LBL)
WALKER .  73 TO BE PUB.         R.L.WALKER,W.J.METCALF                 (CIT)

                                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. OXFORD)

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Δ(1670) D33

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         10  N*3/2(1670, JP=3/2-) I=3/2

         FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
         PRECEDING N*1/2(1470).

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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     (1722.0)                   AYED      70 IPWA                      1/71
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

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Baryons
Δ(1670), Δ(1690), Δ(1890)

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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
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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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(1236) PI                   1236+ 139

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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

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.

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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            +.068     .042          OBERLACK   72 DPWA    PI N PHOTO-PROD  2/73*

A2      N*3/2(1670) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)
A2            +.022     .052          OBERLACK   72 DPWA    PI N PHOTO-PROD  2/73*

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                                  REFERENCES FOR N*3/2(1670)

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
OBERLACK 72 PL 43B 44             H.OBERLACK,R.G.MOORHOUSE              (LBL)

                                  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)

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Δ(1690) P''_{33}

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                    19  N*3/2(1690, JP=3/2+) I=3/2

                    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                    PRECEDING N*1/2(1470).

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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 -DONNACH1, 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

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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

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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

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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

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.

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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 CONF             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

                                  PAPERS NOT REFERRED TO IN DATA CARDS.

AYED     70 PL 31B 598            +BAREYRE,VILLET                     (SACLAY)
BOWLER   70 NP 17B 331            +CASHMORE                       (U. OXFORD)

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Δ(1890) F_{35}

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                    11  N*3/2(1890, JP=5/2+) I=3/2

                    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                    PRECEDING N*1/2(1470).

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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          (1890.0)                   MEHTANI    72 DPWA    PI+P TO D1236 PI  1/73*

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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           (300.0)                   MEHTANI    72 DPWA    PI+P TO D1236 PI  1/73*
            SEE NOTES ACCOMPANYING MASSES QUOTED AS FOR N*1/2(1910)

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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(1236) PI                   1236+ 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+ 770

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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

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) OF 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 D(1236) PI           SQRT(P1*P4)
R4             (0.23)                 MEHTANI    72 DPWA                      1/73*

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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            (+.044)                 WALKER     73 DPWA    PI N PHOTO-PROD  2/73*

A2      N*3/2(1890) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)
A2            (-.027)                 WALKER     73 DPWA    PI N PHOTO-PROD  2/73*

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                                  REFERENCES FOR N*3/2(1890)

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)
WALKER   73 TO BE PUB.            R.L.WALKER,W.J.METCALF                (CIT)
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Data Card Listings

For notation, see key at front of Listings.

Baryons
Δ(1890), Δ(1910), Δ(1950)

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                         PAPERS NOT REFERRED TO IN DATA CARDS.

AYED     70 PL 31B 598       +BAREYRE+VILLET                     (SACLAY)

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Δ(1910)

12 N*3/2(1910, JP=1/2+) I=3/2 **P_{31}**

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             FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
             PRECEDING N*1/2(1470).

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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

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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
           SEE NOTES ACCOMPANYING MASSES QUOTED

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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) INTO N*3/2(1236) PI                 1236+ 139
P5      N*3/2(1910) INTO GAM NUCLEON, HELICITY=1/2         0+ 938
P6      N*3/2(1910) INTO N RHO                           938+ 770

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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

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.

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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           (-.027)               WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

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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
WALKER   73 TO BE PUB.        R.L.WALKER,W.J.METCALF                 (CIT)

                              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)

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Δ(1950)

83 N*3/2(1950, JP=7/2+) I=3/2 **F_{37}**

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             FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
             PRECEDING N*1/2(1470).

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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     (1946.0)                 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.)    (20.)         MEHTANI   71 MPWA ++ PI+P 1.8-2.1 GEV  2/72
M         (1930.)                  ROYCHOUD  71 DPWA                      3/72
M   7     (1925.)                  ALMEHED   72 IPWA                      2/72
M         (1920.0)                 MEHTANI   72 DPWA    PI+P TO D1236 PI  1/73*

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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         (227.)    (12.)    (30.) MEHTANI   71 MPWA ++ PI+P TO (1236)PI  2/72
W   7     (200.)                   ALMEHED   72 IPWA                      2/72
W         (269.0)                  MEHTANI   72 DPWA    PI+P TO D1236 PI  1/73*
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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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(1236) PI                 1236+ 139
P4      N*3/2(1950) INTO Y*1(1385) K                    1384+ 493
P5      N*3/2(1950) INTO N*3/2(1236) RHO                1236+ 770
P6      N*3/2(1950) INTO NEUTRON PI+ PI+                 939+ 139+ 139
P7      N*3/2(1950) INTO N*3/2(1236) PI PI (NOT RHO)    1236+ 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+ 770

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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)               DONNACH1  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
      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 D(1236) PI           SQRT(P1*P3)
R3            0.23     0.04        FUNG      68 HBC  ++ PI+P TO PI+PIO P 11/68
R3            0.24     0.01    0.03 MEHTANI  71 MPWA ++                   2/72
R3           (0.48)                MEHTANI   72 DPWA                      1/73*
R3          . . . . . . . . . .
R3  AVG       0.238    0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

    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           (-.059)               WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

A2      N*3/2(1950) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)
A2           (-.089)               WALKER    73 DPWA    PI N PHOTO-PROD   2/73*

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                           REFERENCES FOR N*3/2(1950)

DUKE     65 PRL 15 468        +JONES,KEMP,MURPHY,PRENTICE, +   (RHEL,OXF)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)
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)
FUNG     68 VIENNA CONF.      FUNG, KERNAN, KALMUS, BIRGE (RIVERSIDE,LRL)

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)

MEHTANI  71 AMSTERDAM CONF.   +FUNG,KERNAN,WILLIAMSON+BIRGE,++  (UCR,LBL)IJP
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)
WALKER   73 TO BE PUB.        R.L.WALKER,W.J.METCALF                 (CIT)

                              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)

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Baryons
Δ(1960), Δ(2160)

Data Card Listings
For notation, see key at front of Listings.

Δ(1960) D_{35}

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13  N*3/2(1960, JP=5/2-) I=3/2

  A NEW PRELIMINARY ANALYSIS BY AYED 72 FINDS
EVIDENCE FOR THIS EFFECT AT 1870 NEV.  SEE THE N*
MINI REVIEW.

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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         (1824.0)                  MEHTANI   72 DPWA    PI+P TO D1236 PI  1/73*

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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          (138.0)                  MEHTANI   72 DPWA    PI+P TO D1236 PI  1/73*

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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
P4      N*3/2(1960) INTO N*3/2(1236) PI                   1236+ 139

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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

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 D(1236) PI             SQRT(P1*P4)
R3            (0.19)                MEHTANI   72 DPWA                      1/73*

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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
MEHTANI  72 PRL 29 1634         +FUNG, KERNAN, SCHALK, +        (UCR +LBL)

                                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)
AYED     72 BATAVIA CONF        R AYED,P BAREYRE, Y LEMOIGNE          (SACL)

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Δ(1950) BUMPS

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70  N*3/2(1950, JP=    ) I=3/2   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*

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                  70  N*3/2(1950) WIDTH (MEV) (PROD. EXP.)

W           (256.0)   (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*

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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(1236) PI                   1236+ 139
P4      N*3/2(1950) INTO Y*1(1385) K                      1384+ 493
P5      N*3/2(1950) INTO N*3/2(1236) RHO                  1236+ 770
P6      N*3/2(1950) INTO NEUTRON PI+ PI+                   939+ 139+ 139
P7      N*3/2(1950) INTO N*3/2(1236) PI PI (NOT RHO)      1236+ 139+ 139

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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

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(1236) 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(1236) 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(1236) 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(1236) RHO)/TOTAL         (P5)
R8           SEEN                   YOON      67 HBC  +                    8/67
R8           NOT SEEN               BOGGILD   70  HBC    PP TO N3PI(NTRL)  6/70

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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)

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Δ(2160) P'''_{33}

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9  N*3/2(2160, JP=3/2+) I=3/2

ROYCHOUDHURY 71 FIND POSSIBLE EVIDENCE FOR P31,D33,AND
D35 RESONANCES IN THIS MASS REGION. IN A SIMILAR ANALYS
BRANSDEN 71 FOUND SOME EVIDENCE FOR S31,D33,AND D35 RES
NANCES INTHIS REGION. VON SCHLIPPE 72 SUGGESTS A G39.

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                   9  N*3/2(2160) 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

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                   9  N*3/2(2160) WIDTH (MEV)

W   3      (260.)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W   7      (200.)                   ALMEHED   72 IPWA                      2/72

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                   9  N*3/2(2160) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      N*3/2(2160) INTO PI N                              139+ 938

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                   9  N*3/2(2160) BRANCHING RATIOS

R1      N*3/2(2160) INTO (PI N)/TOTAL                    (P1)
R1  3          (.25)                KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1  7         (0.3)                 ALMEHED   72 IPWA                      2/72

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                          REFERENCES FOR N*3/2(2160)

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

                                PAPERS NOT REFERRED TO IN DATA CARDS.

DONNACHI 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
VON SCHL 72 LNC 4 767           VON SCHLIPPE                         (LOWC)IJP .

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Data Card Listings

For notation, see key at front of Listings.

Baryons

Δ(2420), Δ(2850), Δ(3230)

Δ(2420)

H_3 11

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84  N*3/2(2420, JP=11/2+)  I=3/2

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          (2400.)                 ROYCHOUD   71 DPWA                     3/72
M          (2440.)                 OTT        72 MPWA  0 PI-P BKWD ELSTC  2/73*

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                      84  N*3/2(2420) WIDTH (MEV)

W    6      (347.0)                AYED       70 IPWA                     1/71

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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         (94)                OTT        72 MPWA  0 PI-P BKWD ELSTC  2/73*

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                                 REFERENCES FOR N*3/2(2420)

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

                                 PAPERS NOT REFERRED TO IN DATA CARDS.

BELLAMY  67 PRL 19 476          +BUCKLEY,DOBINSON, +      (WESTFIELD,LOUC) JP

AYED     70 PL 31B 598          +BAREYRE+VILLET                    (SACLAY)

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Δ(2420) BUMPS

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69  N*3/2(2420, JP=    ) I=3/2   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 PHOTOPROD     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    B  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(1236) PI               1236+ 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           0.0195    0.0048      GALLOWAY  68 RVUE                     6/68

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                                 REFERENCES FOR N*3/2(2420) (PROD. EXP.)

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 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
GALLOWAY 68 PL 26B 334          K F GALLOWAY                      (INDIANA) I

                                 PAPERS NOT REFERRED TO IN DATA CARDS.

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
    COMPLEX ELASTIC SCATTERING AMPLITUDE AT 0 DEGREES.

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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  0 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

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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

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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.

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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

                                 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 0 DEGREES.

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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

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                  86  N*3/2(3230) WIDTH (MEV) (PROD. EXP.)

W         (440.0)                        CITRON    66 CNTR                   7/66

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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
R2  B  FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
R1  D        (0.25)                    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*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)

                            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 NUCLEON

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          THIS IS NOT A COMPLETE LIST. WE WILL TABULATE EXOTICS FROM NOW ON
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EX(1640)

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                  92  EX(1640, JP=     ) I=5/2

                  AMMANN 71 AND JOHNSON 71 WITH COMPARABLE (OR
                  BETTER) STATISTICS AND AT MOMENTA NEAR 4.91 ARGUE
                  STRONGLY THAT THE EFFECT SEEN BY PRICE 70 IS A
                  STATISTICAL FLUCTUATION.

                  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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                  92  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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                  92  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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                  92  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 Possible Z^*'s

Although much work has been done on the strangeness +1 reactions during the past few years, it is not yet clear whether the peaks seen in total KN cross sections near 1 GeV/c are resonances; see Fig. 1. Since positive-strangeness baryons cannot be made from three quarks, it is very important to find out if these peaks are resonances.

(a) I = 0 System. New K^+p total cross section data have been reported by the Arizona group in the 0.57 to 1.16 GeV/c region (BOWEN 73) and by the BNL group (CARROLL 73) in the 0.4 to 1.06 GeV/c region. The cross-sections of both groups fail to exhibit the dip at 0.7 GeV/c previously reported. The absence of the dip is also observed in the K^+p elastic data reported by ADAMS 72. A curve through the K^+p total cross section data as drawn by CARROLL 73 is shown in Fig. 1. The new K^+d cross section data around 0.7 GeV/c also show smoother behavior than before, and both effects result in the I = 0 cross section shown in Fig. 1. The data points after unfolding and the smooth curve drawn by CARROLL 73 are shown in Fig. 2a. The double humped structure reported by ABRAMS 69, COOL 70, and DOWELL 70 now looks more like a shoulder and a bump, which is associated with the rapid increase in the inelastic cross section.

Fig. 2a shows large disagreement at low momenta between BOWEN 73 and CARROLL 73 points. However, only part of this disagreement is due to a difference in the measured K^+d cross sections (for $P > 0.8$ GeV/c, there is no systematic difference between the two sets of data); the rest can be attributed to differences in the unfolding procedures.

There is, however, no doubt about there being a large broad peak in the isospin 0 elastic cross section. The inelastic cross section increases smoothly until the K^*N threshold at 1.08 GeV/c is approached where, as shown in Fig. 2b, the K^*N cross section comes in strongly (HIRATA 70). The total $KN\pi$ and $KN\pi\pi$ cross sections are shown in Fig. 1 as eyeball curves drawn through the data (GIACOMELL1 72). Subtracting these from the total cross section one gets σ_0(elastic) also shown in Fig. 1. The resonance (if it

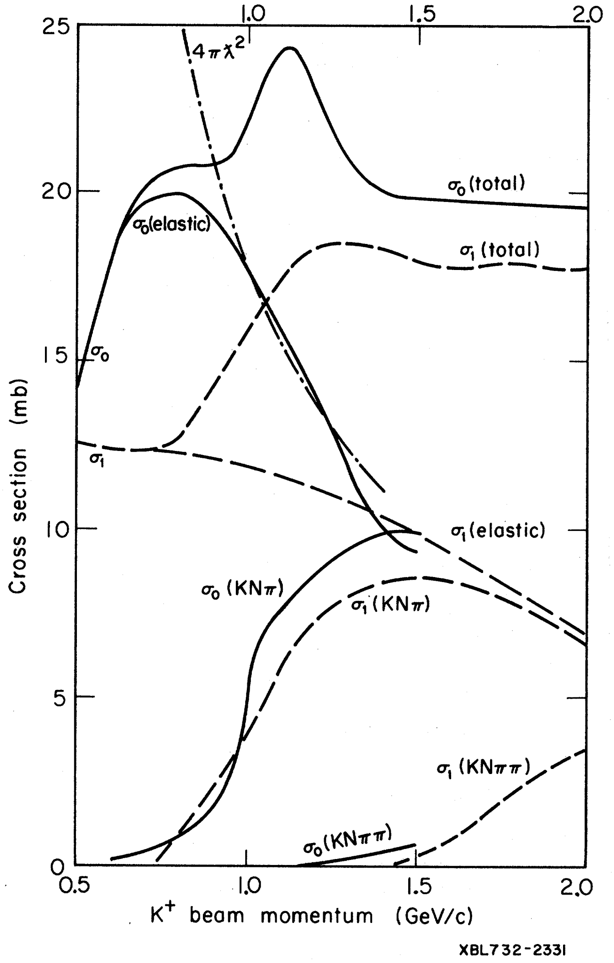

Fig. 1. KN total and partial cross sections. Subscripts indicate isospin. Total cross section curves from CARROLL 73, which uses new data of BOWEN 73 as well as previous data. Elastic I=1 curve is hand-drawn through new and old elastic data. I=0 inelastic curves taken from GIACOMELLI 72. Isospin 1 inelastic curves taken from LOKEN 72.

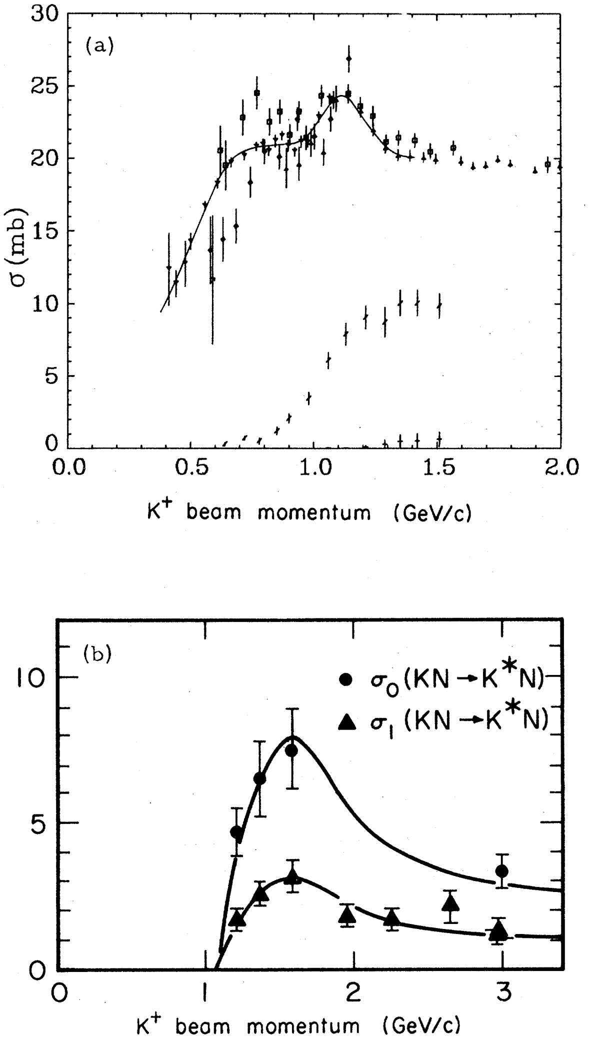

Fig. 2.
(a) Unfolded I=0 cross sections as quoted by the various authors discussed in the Z* mini-review:

◊ BOWEN 73 σ_T
□ BUGG 68 σ_T (as unfolded by CARROLL 73)
▽ CARROLL 73 σ_T
△ COOL 70 σ_T
⁄ GIACOMELLI 72 σ(πKN)
- GIACOMELLI 72 σ(ππKN)

(b) Energy dependence of the isospin 0 and isospin 1 cross sections for the reaction KN → K*N (HIRATA 70).

exists) would have a mass M ~ 1780 MeV, would be very wide, and would be very elastic because the inelastic cross section is small at the peak. If J were greater than 1/2, the resonant peak would exceed the observed height of ~ $4\pi\lambda^2$. This fixes the spin as 1/2, and means that there is little cross section left over for other partial waves. Of course it is quite possible that in fact the peak is not caused by a resonance at all.

Differential cross section data on the elastic charge exchange have been reported by HIRATA 71 (5 momenta in the 0.87 to 1.59 GeV/c region) and by GIACOMELLI1 72 (13 momenta in the 0.64 to 1.51 GeV/c region). More recently GIACOMELLI2 72 reported data on the $K^+n \to K^+n$ elastic scattering in the 0.6 to 1.6 GeV/c region, and ARMITAGE 72 has reported very preliminary data of $K^0p \to K^+n$. Attempts to perform partial-wave analyses for the I = 0 system have also been reported recently. HIRATA 71, which does not include the most recent elastic and total cross section data, finds a large P_{01} partial wave which does not go through 90° as expected for an elastic resonance. WILSON 72 report energy-dependent and energy-independent analyses, which did not include the K^+n elastic data. S, P, and D waves only were included in the fit and six classes of solutions were found. The addition of the K^+n data has reduced the solutions to four with two being favored over the others (called C and D).[1] Solution D shows a resonant-like P_{01} partial wave which crosses the imaginary axis at P = 1200 MeV/c and turns back in toward the center of the Argand plot. The other solution also has a large P_{01} partial wave, but it does not look resonant. Note, however, that very little polarization data have gone into these analyses; therefore a conclusion on the existence of $Z_0^*(1780)$ must await more data.

(b) I = 1 System. As discussed above there are new elastic cross section data reported by ADAMS 72 (0.4 to 0.9 GeV/c) and new K^+p total cross section measurements by BOWEN 73 and CARROLL 73. Elastic cross section results have also been reported by CHARLES 72 (0.9 to 1.9 GeV/c). For the inelastic channels new data have been reported by LOKEN 72. Fig. 1 shows smooth curves drawn through the new total cross section data, the new elastic data, and the inelastic data of LOKEN 72.

Many partial-wave analyses have been performed on the K^+p data since the I = 1 bump first appeared in 1966. We mention here only the most recent ones and refer the reader to our previous edition for a review of the others.[2] MILLER 72 has reported an analysis which uses a new method, ACE (accelerated convergence expansion), in which high partial waves are included through conformal mapping as suggested by CUTKOSKY 70. The results of ACE are then compared with the two solutions obtained by the same group through conventional partial-wave analysis. CUTKOSKY 72 is a new analysis by the same group with energy smoothing added to a more extensive random search. CHARLES 72 have performed a comparison of their data to existing phase-shift analysis and find that the ALBROW 71 α, β, γ solutions are the preferred ones, although they cannot choose among them. EHRLICH 72 have reported an analysis of data between 1.3 and 2.3 GeV/c employing the ACE method. Then they use the shortest path method to link the energy-independent solutions and find 25 least path solutions, some resembling previously published solutions, in addition to new ones. Another new analysis has been reported by Martin and Miller (MARTIN 72), who use an energy-dependent parametrization based on partial-wave dispersion relations. As a starting point the ALBROW 71 solution γ is used and they obtain a new solution which is not very different from the starting one.

In conclusion the new analyses, as the old ones, yield more than one solution to choose from, which indicates that the data are not good enough to eliminate some of the possibilities. More data of the conventional type, measurements of the R and A parameters, and the simultaneous analysis of elastic and

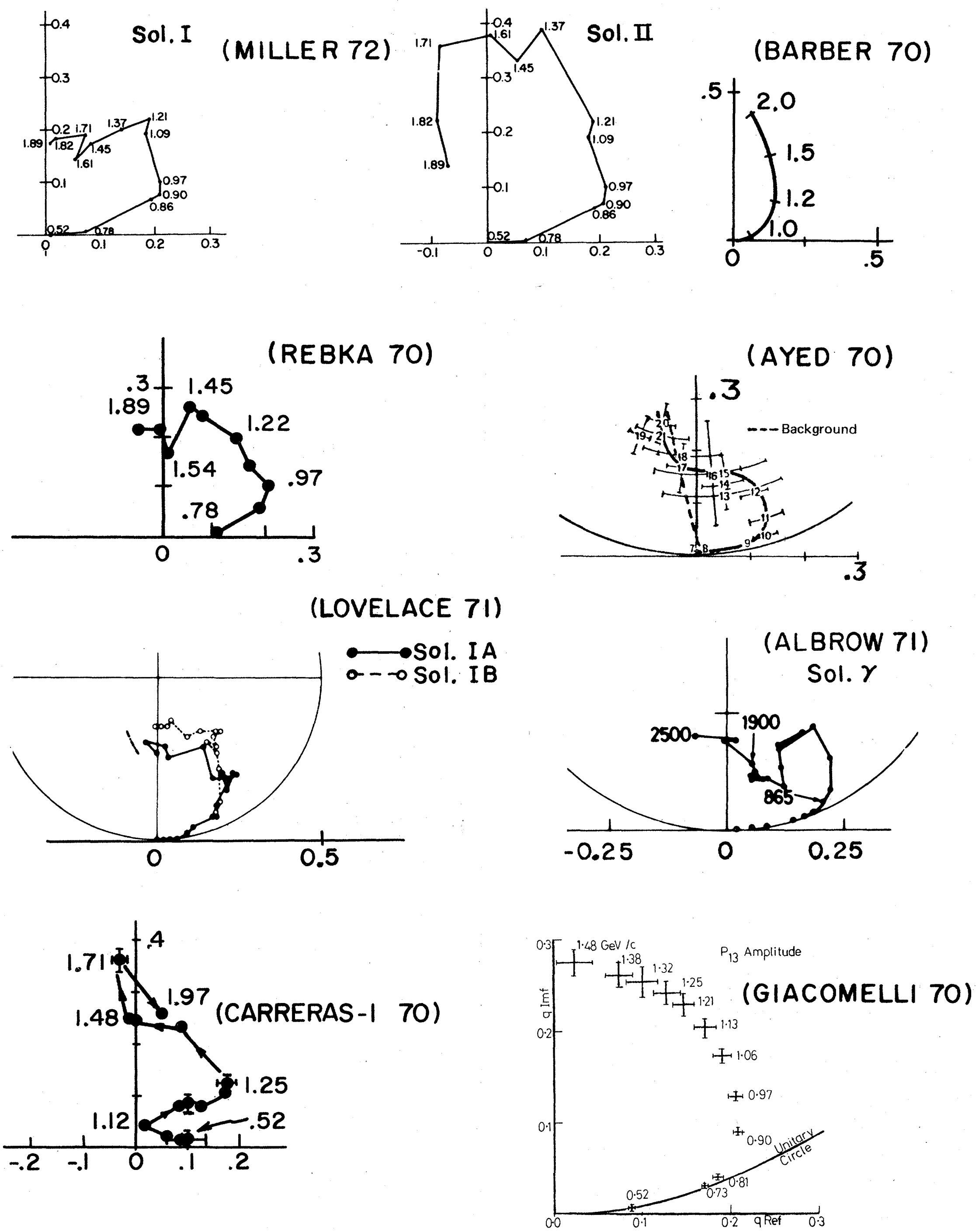

Fig. 3. Argand plots for the P_{13} partial wave as obtained in partial-wave analyses performed by the authors indicated. (CARRERAS-1 70 plotted by us from η, δ.)

inelastic channels (copious inelastic data are desirable at the moment) could improve the understanding of this system.

The P_{13} amplitude still remains the best candidate for a resonance in the K^+p system. The preferred P_{13} Argand plots obtained by some of the groups are shown in Fig. 3. Each analysis in one way or another gets at least one solution with a counterclockwise P_{13} amplitude. Resonant P_{13} is preferred by REBKA 70, GIACOMELLI 70, and ALBROW 71; the results of the other analyses are not so clear cut.

Threshold effects. An alternative way to describe the P_{13} amplitude would be in terms of a coupled-channel threshold effect: the KN amplitude becomes rapidly absorptive as it feeds the rapidly increasing $K\Delta$ channel. The main question still remains: Is it also a resonance? If it is, its elasticity is small (≈ 0.2) and it decays mainly into $K\Delta$. Partial-wave analyses in this channel do not seem to favor the resonant hypothesis at this time. See BLAND 67, BLAND 70, and GRIFFITHS 72. But a definite conclusion has yet to be made and awaits much more data.

Production experiments. One more comment on exotic resonances is that, as pointed out by ERNE 70, the present upper limits for the cross sections for production of broad exotic resonances are not very small; that is, they are of the same order as cross sections for Y^* or N^* production.

References

1. A description of the new WILSON 72 analysis as well as an excellent review of recent work on the Z^*'s can be found in: J. D. Dowell, "The Search for Z^*'s", Proceedings of the XVI International Conference on High Energy Physics, Chicago-Batavia (1972).
2. Particle Data Group, Physics Letters 43B, No. 1 (1972).

$Z_0(1780)$

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95  Z*0(1780, JP=1/2 ) I=0

SEE THE MINI-REVIEW PRECEDING THIS LISTING.

THIS EFFECT, 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.

            HIRATA 71 ARGUE THAT IT IS THE P01 WAVE THAT
IS LARGE. HOWEVER, THEY CONCLUDE THAT P01 NEED NOT PASS THROUGH 90
DEGREES TO EXPLAIN THE RELEVANT DATA IN THE 1 GEV/C REGION.
  WILSON 72 FIND SOME SOLUTIONS WITH RESONANT-LIKE BEHAVIOR IN THE P01
PARTIAL WAVE.

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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

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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

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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

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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)

                            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)
CARROLL   73  BNL PREPRINT      +KYCIA,LI,MICHAEL,MOCKETT              (BNL)

     EXPERIMENTS MAINLY ABOUT ELASTIC CHANNELS --
ARMITAGE 72  NAL PAPER 391      +ASTON,DUERDOTH,ELLISON,  +      (MCHS+DARE)
GIACOME1 72 NP B42 437          GIACOMELLI +          (BGNA+GLAS+ROMA+TRST)
GIACOME2 72  NP SUBMITTED       GIACOMELLI +          (BGNA+GLAS+ROMA+TRST)

     EXPERIMENTS MAINLY ABOUT INELASTIC CHANNELS --
GIACOMEL 72 NP B37 577          GIACOMELLI +          (BGNA+GLAS+ROMA+TRST)

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$Z_0(1865)$

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96  Z*0(1865, JP=    ) I=0

THIS EFFECT IS STRONGLY ASSOCIATED WITH THE K* N
THRESHOLD. SEE HIRATA 68 AND 70. WILSON 72 REPORTS A
PARTIAL WAVE ANALYSIS.  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

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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

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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+ 891

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                    96  Z*0(1865) BRANCHING RATIOS

R1     Z*0(1865) INTO (K N)/TOTAL                        (P1)
R1          (0.31)   (0.05)          CARTER    67 THEO     IF J=1/2          8/67
R1          (0.40)   (0.05)          COOL      70 CNTR     IF J=1/2          8/67

R2     Z*0(1865) INTO N K*(892)                          (P2)
R2              MAIN INELASTIC DECAY   HIRATA    68 HBC                     11/68

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Baryons

$Z_0(1865)$, $Z_1(1900)$, $Z_1(2150)$, $Z_1(2500)$

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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)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

HIRATA    70 DUKE   429          +GOLDHABER,SEEGER,TRILLING+WOHL         (LRL)
AARON     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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$Z_1(1900)$

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97   Z*1(1900, JP=    ) I=1

THIS EFFECT IS STRONGLY ASSOCIATED WITH THE K N*
THRESHOLD.  IF A RESONANCE, THE SPIN-PARITY IS ALMOST
CERTAINLY 3/2+.
SEE THE MINIREVIEW PRECEDING Z*0

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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 SOLNS IN ORDER OF DECREASING SIGNIFICANCE. THOUGH AYED 70
M   1      GIVE PARAMETERS,THEY CONCLUDE RESONANT INTERPRETATION DOUBIFUL.
M   2     (1840.0)                    BARNETT   70 IPWA    P13,SOLN III     7/70
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      (397.0)                    AYED      70 IPWA    K+P              6/70
W   1      (557.0)                    AYED      70 IPWA    K+P              6/70
W   2       (80.0)                    BARNETT   70 IPWA    K+P EIPWA        7/70
W          (240.0)                    COOL      70 CNTR ++ K+P 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  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(1236) K                     1236+ 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         (0.09)                  BARNETT   70 IPWA    K+P EIPWA        7/70
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(1236)                       (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 DUKE   443          +GOLDMAN,LAASANEN,STEINBERG      (MARYLAND)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

                                 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  BNL PREPRINT       +KYCIA,LI,MICHAEL,MOCKETT               (BNL)
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     A K-MATRIX ANALYSIS OF SOME OF THE EARLY K+P DATA ---
HITE      67 THESIS              G E HITE                           (ILLINOIS)

     REGGE-POLE ANALYSES --
CARRERAS 70 NP B19 349           B CARRERAS, A DONNACHIE  (DARESBURY, MCHS)

     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)
GRIFFITH 72 NP B38 365           +HIRATA,HUGHES,JACOBS+(BGNA,GLAS,ROMA,TRST)IJP
LOKEN     72 PR D6 2346          +BARISH,GOMEZ,DAVIES,SCHLEIN,+   (CIT,UCLA)

     THE MAIN ELASTIC SCATTERING AND POLARIZATION EXPERIMENTS --
CARROLL   68 PRL 21 1282         +FISCHER, LUNDBY, PHILLIPS, +    (BNL,ROCH)
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+NAL)
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)

     PHASE SHIFT ANALYSES
CARRERA1 70 NP B23 525           B CARRERAS, A DONNACHIE            (DARE)IJP
    ALSO 70 DUKE 447             +DONNACHIE,KIRSOPP      (DARE+MCHS+    EDIN)
LEA       71 NP  B26 413         +MARTIN,THOMPSON                (RHEL,LOUC)IJP
LOVELACE 71 NP  B28 141          +WAGNER                            (CERN)IJP
EHRLICH   72  NAL PAPER 447      +ETKIN,GLODIS,HUGHES,LU,PATTON +      (YALE)
CUTKOSKY 72  NAL PAPER 210       +HICKS,KELLY,SHIH,JOHNSON    CARN+ILL+ANL
MARTIN    72  PREPRINT           B.R.MARTIN, C.E.MILLER               (LOUC)

     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
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)

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$Z_1(2150)$

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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

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                        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)

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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$Z_1(2500)$

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94   Z*1(2500, JP=    ) I=1

A SMALL BUMP IN TOTAL CROSS SECTION AT
PK=2.7 GEV/C

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                        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

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                 94  Z*1(2500) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Z*1(2500) INTO K N                             493+ 938

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                 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)

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

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        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

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                                REFERENCES FOR Z*1 CROSS SECTION LIMITS

BASSOMPI 68 PL 27B 468          BASSOMPIERRE, +                (CERN,BRUXELLES)
ANDERSON 69 PL 29B 136          +BLESER, BLIEDEN, COLLINS, + (BNL,CARNEGIE)

                                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 Y^*'s

The number of known or suspected Y^* states has increased considerably in the last few years, following closely a similar increase in the number of N^* states. Just as the recently discovered N^*'s are only weakly coupled in the $\pi N \rightarrow \pi N$ reaction, so also are the recently discovered Y^*'s only weakly coupled in the $\bar{K}N \rightarrow \bar{K}N$, $\bar{K}N \rightarrow \Lambda\pi$, and $\bar{K}N \rightarrow \Sigma\pi$ reactions. For this reason the newer Y^*'s are more difficult to uncover; they usually appear as small peaks in invariant mass distributions or make no appearance at all. Rather when the 2-body reactions are partial-wave analyzed, some of the amplitudes are found to traverse resonance-like counterclockwise circles. Clearly the results of partial-wave analysis give the 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.

Production experiments. These types of experiments are often difficult to analyze. Information on I = 0 states is possible only when there is no I = 1 state at similar mass. The main controversies at the present time concern resonances in the 1600 to 1700 MeV region. See the mini-reviews on Σ(1620) and on Σ(1670) in these Listings. A good review is given by MILLER 70.[1] Also, the branching ratios of Σ(1915) F_{15} as measured in formation and productions experiments do not agree. This is probably due to two facts: 1) the elasticity is small, 2) the nearby D_{13}(1940) may contribute to production experiments.

Formation experiments. Partial-wave analyses have been performed on $\bar{K}N$, $\Lambda\pi$, $\Sigma\pi$ and ΞK channels. Given the present accuracy of the data it is not possible to perform a completely energy-independent analysis, that is, solve for the partial-wave amplitudes at each energy in a model-independent way. Usually many solutions are found and even when it is required that solutions at neighboring energies join smoothly, it is not possible to select a unique overall solution. To overcome this, one specifies the form of the energy dependence of some or all of the partial-wave amplitudes. Analyses in which the energy dependence of all the amplitudes is specified are called energy dependent. When referring to results of this type of analysis, the technique listed is DPWA. Thus an amplitude known to resonate will be given a Breit-Wigner form, whereas an amplitude not a priori known to resonate may be tried alternately with a resonance form and with some simple nonresonant form, the choice between these then being made by comparing the goodness-of-fit for the two fits. Analyses in which the energy dependence of most of the amplitudes is left unspecified are called (not quite correctly) energy independent. These may involve some fixed input resonances in some of the partial waves and/or some method for selecting solutions that join together smoothly as functions of energy. The technique used for these analyses is listed as IPWA.

Three recent analyses have attempted to fit data on three channels ($\bar{K}N$, $\Sigma\pi$, and $\Lambda\pi$) at lab momenta below 1226 MeV/c. ARMENTEROS 70 (CH) fit each channel separately. They first fit Legendre series to the available data at each momentum in the range 436-1200 MeV/c, and then obtained smooth curves through the Legendre coefficients by fitting a polynomial in

p_{lab} to each coefficient. Finally, the partial wave amplitudes were fit to the smoothed Legendre coefficients (or reconstructed smoothed angular distributions in the case of $\bar{K}N$), and the continuity of the "data" was used to enforce continuity of the amplitudes. With a few exceptions the S and P waves were varied freely, while the higher waves were fixed as sums of Breit-Wigners (BW's) with no background, representing some well known resonances. Single channel inelastic unitarity was imposed during the fitting, and the results were checked against the three-channel unitarity constraint

$$\mathrm{Im}\, T_{\bar{K}N} \geq |T_{\bar{K}N}|^2 + |T_{\Sigma\pi}|^2 + |T_{\Lambda\pi}|^2 \qquad (1)$$

for each isospin. Resonance parameters were estimated visually.

KIM 71 (K) fit data from threshold to 1226 MeV/c using the Ross and Shaw[2] effective-range expansion of the inverse multi-channel K-matrix. The data in each of seven energy intervals bounded by 0, 534, 658, 806, 916, 1022, 1117, and 1226 MeV/c, were fit with a constant effective-range matrix. An extra channel was included for each isospin to approximate the effects of three-particle final states. The parameters for these extra channels were constrained by information on the total three-particle cross sections. Only the $F_{15}(1915)$ was fixed to a BW form, all other waves included being parametrized by the K-matrix formalism. Resonances were identified on the basis of loops in the Argand diagram correlated with a peak in the speed plot and a pole in the K-matrix. The radius of the loop, the speed criterion, and the residue of the K-matrix were used to determine resonance parameters.

LANGBEIN 72 (LW) performed single energy fits at 40 momenta between 436 and 1226 MeV/c. The partial waves at each energy were parametrized in a form that automatically satisfied Eq. (1), and that could easily be specialized to a BW form by setting one of the parameters to zero. This capability was used to constrain the $D_{03}(1690)$, $D_{15}(1765)$, $F_{05}(1815)$, and $F_{17}(2030)$ to pure BW forms in the range $|E-M_R| < \Gamma$. The resonant parameters were fit to known values. Approximately 90 acceptable single-energy fits per energy were generated and were used in shortest path searches over two regions, 1536 to 1700 MeV and 1700 to 1900 MeV. Several candidates for acceptable shortest paths were generated, and a preferred path was chosen by rejecting those that failed to reproduce known resonance behavior. Resonances in this solution were identified by loops in Argand diagrams correlated with peaks in the ≥3-body final state cross section. Resonance parameters were then extracted by fitting BW's with both multiplicative and additive background.

Partial-wave amplitudes from these three analyses are shown in Figs. 1-3. These analyses show, in addition to the well-established states (which we have classified with three or four stars in Table II at the end of this note), other states which we report in Table I. The table includes effects which show as a clear signal in at least one of the analyses (i.e., this is a list of promising "rookies").

Table I. Comparison of recent Y^* claims. Notation is mass (MeV)/width (MeV)/strongest two-body channel; CH = CERN-Heidelberg, K = Kim, LW = Langbein and Wagner.

Wave	CH	K	LW
S_{01}		1780/40/$\bar{K}N$	1830/70/$\bar{K}N$
P_{01}		1570/50/?	1620/60/?
P_{01}	1750/70/$\Sigma\pi$ 1800/30/$\bar{K}N$	1755/35/$\bar{K}N$	1780/120/$\bar{K}N$
P_{03}			1850/125/$\bar{K}N$
S_{11}		1620/40/$\Lambda\pi$	1630/65/$\Sigma\pi$
S_{11}	1730/80/$\Lambda\pi$	1790/50/$\bar{K}N$	1790/100/$\bar{K}N$
P_{11}	1500-1600/50/$\Sigma\pi$	1670/50/$\Sigma\pi$	
P_{13}			1840/120/$\bar{K}N$

Although a certain amount of qualitative agreement is apparent, there are many quantitative discrepancies. Some of these effects have been seen elsewhere, and there is also considerable disagreement with some of these other observations. The branching ratios into $\bar{K}N$, $\Sigma\pi$, and $\Lambda\pi$ are particularly poorly determined (this is also true of some of the better established resonances).

In addition to analyses which treat all of the channels $\bar{K}N$, $\Sigma\pi$, and $\Lambda\pi$, there have been a number of energy-dependent analyses of a single channel. We will describe three of the most recent of these. CONFORTO 71 fit data on the $\bar{K}N$ channel between 777 and 1226 MeV/c. The procedure was to parametrize each wave as a term linear in the lab momentum plus (possibly) BW's with adjustable phase. The data were first fit with BW's representing only known resonances. Three more resonances were then added, one at a time,

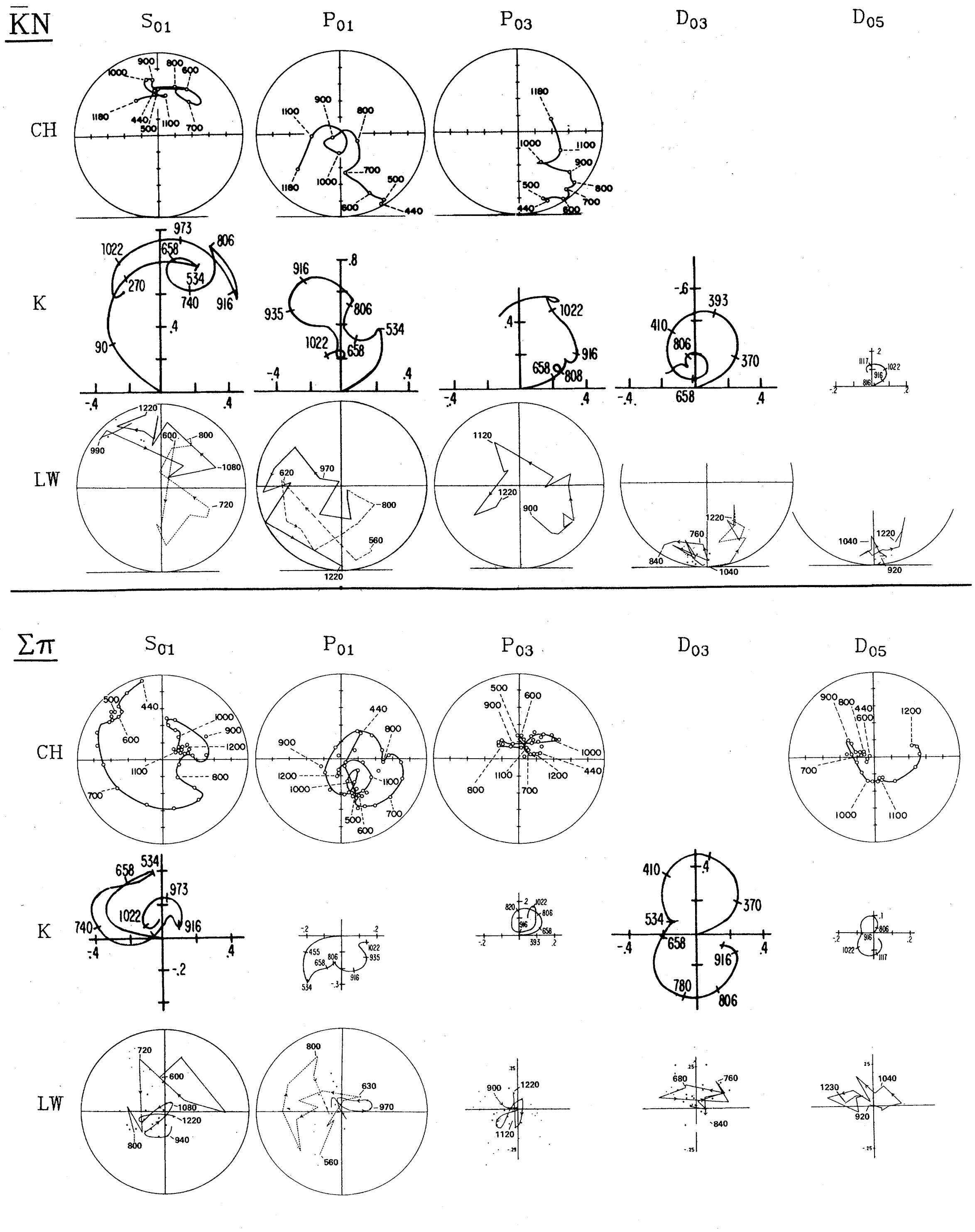

Fig. 1. I=0 partial wave amplitudes for the reactions $\overline{K}N \rightarrow \overline{K}N$ and $\overline{K}N \rightarrow \Sigma\pi$ from the analyses of ARMENTEROS 70 (CH), KIM 71 (K), and LANGBEIN 72 (LW). The $\overline{K}$ laboratory momenta are indicated.

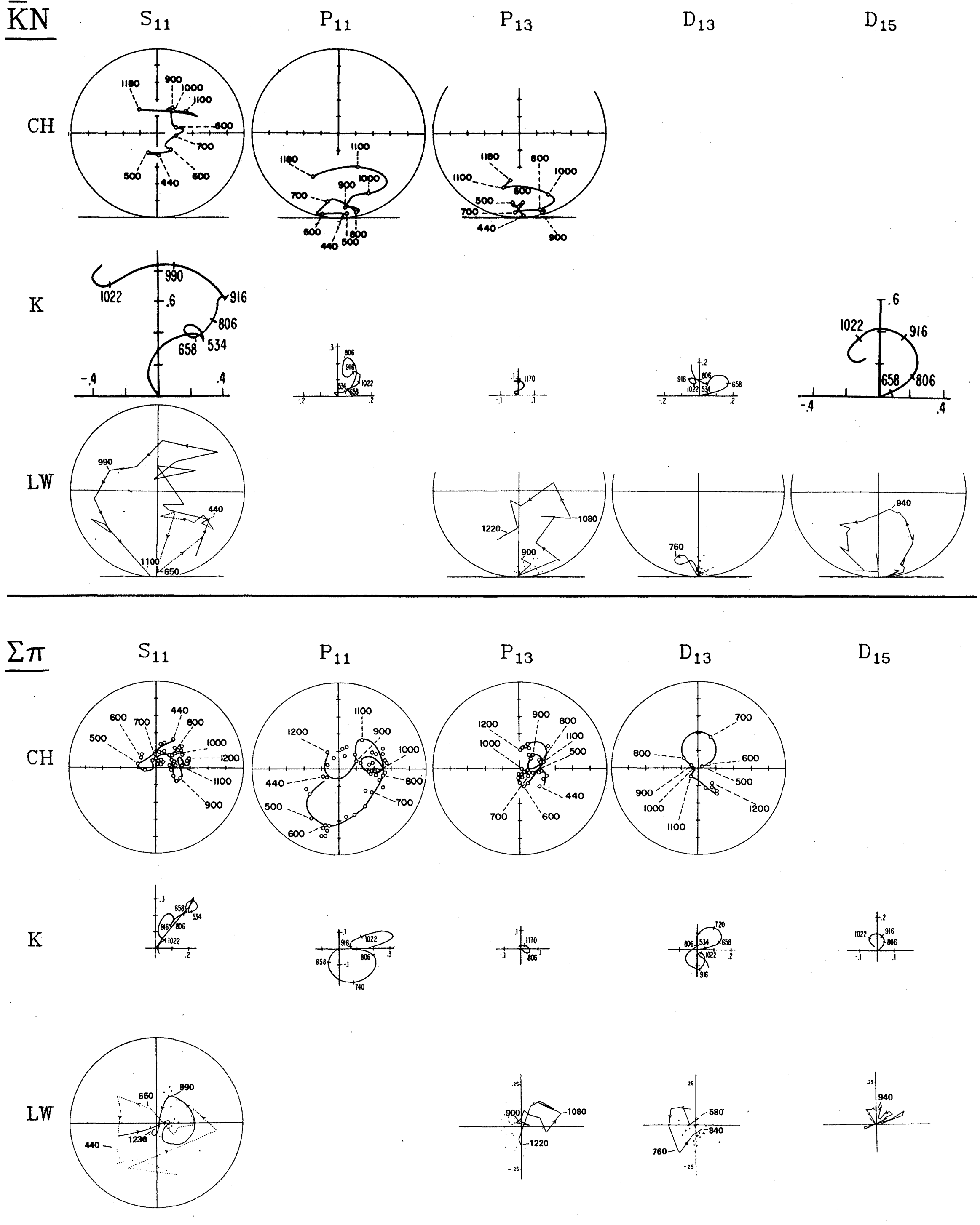

Fig. 2. I=1 partial wave amplitudes for the reactions $\overline{K}N \rightarrow \overline{K}N$ and $\overline{K}N \rightarrow \Sigma\pi$ from the analyses of ARMENTEROS 70 (CH), KIM 71 (K), and LANGBEIN 72 (LW). The $\overline{K}$ laboratory momenta are indicated.

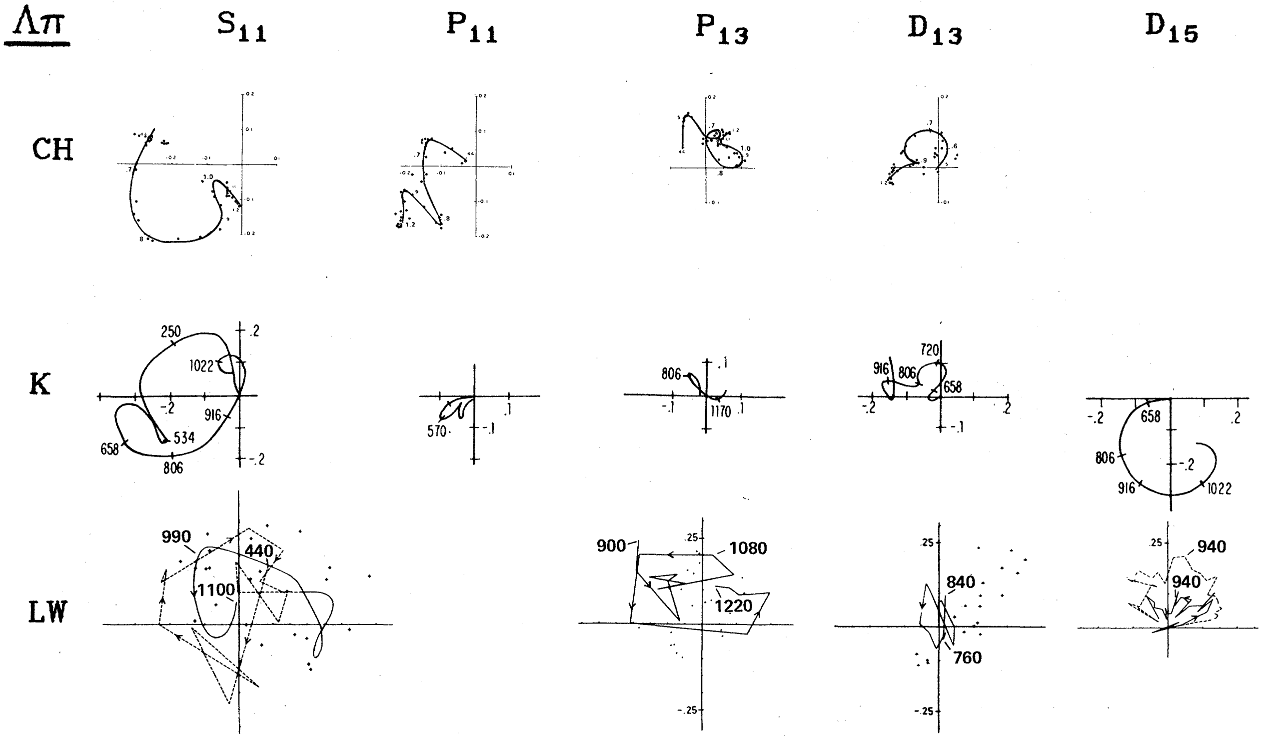

Fig. 3. Partial wave amplitudes for the reaction $\overline{K}N \to \Lambda\pi$ from the analyses of ARMENTEROS 70 (CH), KIM 71 (K), and LANGBEIN 72 (LW). The $\overline{K}$ laboratory momenta are indicated.

to the waves where they had the most effect on χ^2. Best results were obtained by adding a $D_{05}(1830)$, $P_{03}(1883)$, and $S_{11}(1757)$. KANE 72 reported an analysis of bubble chamber cross section and polarization data on the $\Sigma\pi$ channel between 870 and 1694 MeV/c. Legendre coefficients obtained from this data were used to fit an energy-dependent background + BW form for each wave, and the results were checked against the angular distributions from this experiment and against a compilation of Legendre coefficient data. In addition to known resonances, signals for a $F_{05}(2141)$, $F_{15}(2057)$, and a $D_{13}(1985)$ were seen. VAN HORN 72 fit data on the $\Lambda\pi$ channel Legendre coefficients over the range 1537-2215 MeV, including new bubble chamber data between 1865 and 2106 MeV. An energy dependent parametrization similar to KANE 72 was used for the fitting; the 20 best solutions indicate (in addition to established resonances) the probable resonances $S_{11}(1697)$, $D_{13}(1949)$, $P_{11}(1668)$, and four possibilities in other waves. VAN HORN 72 also used the Barrelet[3] method to generate ambiguous solutions that correspond to the same cross sections and polarizations as the best energy-dependent solutions. Seven ambiguous solutions were found that preserved the established resonance behavior of the $D_{13}(1670)$, $D_{15}(1765)$, $F_{15}(1915)$, and $F_{17}(2030)$, but with varying couplings for these resonances to the $\Lambda\pi$ channel, and with widely different resonant structures in the lower waves.

Errors on masses and widths. Often the quoted errors are only statistical, but the values of masses and widths can change well above 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.

Recently it has become the custom to quote errors as obtained by inspection of various fits done with different hypotheses [see for example BERTHON 70 and GALTIERI 70 under Σ(1915)]. These errors are probably more realistic. On the other hand, the value of the parameter itself may be consistent with other determinations and often may even be the best available value. In such circumstances we put only the error in parentheses to remind the reader of the additional uncertainty due to model dependent assumptions. For two states, Λ(1820) and Σ(1765), there is enough data available to perform an overall fit of the various x_i of the type discussed in the main text (section V C). 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 conclusion, we chose not to give errors on masses and total widths determined in partial-wave analyses, but, whenever necessary, we give 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 II 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 definitely are many new resonances underlying those we are more familiar with.

References

1. D. H. Miller, in Proceedings of the Duke Conference on Hyperon Resonances (1970), p. 229.
2. M. Ross and G. Shaw, Ann. Phys. (N. Y.) 13, 147 (1961).
3. E. Barrelet, N.C. 8A, 331 (1972).
4. A. Barbaro-Galtieri in Proceedings of the Duke Conference on Hyperon Resonances (1970), p. 173.

TABLE II. 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					
LAM(1405)	S01	****		****	F	****	
LAM(1520)	D03	****	****	****	O	****	LAM2PI,LAM GAM
LAM(1670)	S01	****		****	R	****	LAM ETA
LAM(1690)	D03	****	****	****	B	****	LAM2PI,SIG2PI
LAM(1750)	P01	**		**	I	**	
LAM(1815)	F05	****	****	****	D	****	SIG(1385) PI
LAM(1830)	D05	***		***	D	****	
LAM(1860)	P03	**	**	**	E	*	
LAM(1870)	S01	**		**	N	*	
LAM(2010)	D03	**			F	*	LAM OMG
LAM(2020)	F07	**		*	O	*	
LAM(2100)	G07	****	****	****	R	***	XI K,LAM OMG
LAM(2110)		*		*	B	*	LAM OMG
LAM(2350)		****	****	****	I		
LAM(2585)		***	***	*	D		
SIG(1190)	P11	****					WEAK TO N PI
SIG(1385)	P13	****			****	****	
SIG(1440)	PE	DEAD					
SIG(1480)	PE	*		*	*	*	
SIG(1620)	S11	**		**	*	*	
SIG(1620)	P11	**		**	*	**	
SIG(1620)	PE	**		*	**		LAM 2-PI
SIG(1670)	D13	****	**	***	****	****	SEVERAL OTHERS
SIG(1670)	PE	**		**	**	**	SEVERAL OTHERS
SIG(1690)	PE	**	*	*	**	*	LAM 2-PI
SIG(1750)	S11	***		**	**	*	SIG ETA
SIG(1765)	D15	****	****	****	****	***	SEVERAL OTHERS
SIG(1840)	P13	*		*	**	*	
SIG(1880)	P11	**		**	**		
SIG(1915)	F15	****	***	***	****	***	
SIG(1940)	D13	***		*	***	**	
SIG(2000)	S11	*			*		
SIG(2030)	F17	****	****	****	****	**	XI K
SIG(2070)	F15	*				*	
SIG(2080)	P13	**			**		
SIG(2100)	G17	**			**	**	
SIG(2250)		****	****	*	*	*	
SIG(2455)		***	***	*			
SIG(2620)		***	***	*			
SIG(3000)		**		*	*		

**** 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.

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Λ

18 LAMBDA (1115,JP=1/2+) I=0

SEE STABLE PARTICLE DATA CARD LISTINGS

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**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 IS SEEN NEAR 1330 MEV IN THE LAMBDA GAMMA SPECTRUM IN THREE PI- PROPANE EXPERIMENTS (YUNG-CHANG 64, BUBELEV 67, AND BOZOKI 68). IN THE FIRST TWO, THIS WAS TAKEN AS INDIRECT EVIDENCE FOR THE Y*0(1670) DECAYING TO LAMBDA ETA, WITH THE ETA DECAYING TO TWO GAMMAS. IN THE THIRD EXPERIMENT THIS INTERPRETATION HAS BEEN RULED OUT. BOZOKI 68 MENTION THE POSSIBILITY OF THERE BEING A Y*0(1330) WITH A NARROW WIDTH (<25 MEV), BUT DEFER SERIOUS CONSIDERATION OF IT UNTIL THERE IS MORE DATA.

SHOULD SUCH A RESONANCE EXIST, IT SHOULD BE SEEN IN PI- P TO KO + (MISSING MASS). DAHL 67 FOUND NO EVIDENCE FOR IT.

A SEARCH FOR A NEW Y*0 NEAR THE LAMBDA OR SIGMA MASS WAS MADE BY TAN 69. NONE WAS FOUND.

ANOTHER SEARCH BY MAYEUR 70 REVEALED NO EVIDENCE FOR THIS STATE.

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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)

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Baryons
Λ(1405), Λ(1520)

Data Card Listings
For notation, see key at front of Listings.

Λ(1405) BUMPS

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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 SEPA-
RATELY BELOW.  WE USE ONLY PRODUCTION EXPERIMENTS FOR
AVERAGING OF MASSES AND WIDTHS.

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                    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)

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                    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)

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                    37  Y*0(1405) PARTIAL DECAY MODES (PROD. EXP.)

                                                               DECAY MASSES
P1     Y*0(1405) INTO SIGMA PI                             1197+ 139

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                              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)

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Λ(1405) EXTRAP.

S'_{01}

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24  Y*0(1405, JP=1/2-) I=0
    EXTRAPOLATION BELOW THRESHOLD

SEE NOTE IN Y*0(1405) PRODUCTION EXPERIMENTS -THE DIF-
FICULTIES IN EXTRAPOLATING FROM THE PHYSICAL REGION TO
THE RESONANCE LOCATION ARE DISCUSSED BY DALITZ 67.

       THE QUESTION ON WHETHER Y*(1405) IS A KRAR-N BOUND
  STATE OR A CDD POLE (DALITZ 70) 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.

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                    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

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                    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

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                              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
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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)

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Λ(1520)

D'_{03}

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38  Y*0(1520, JP=3/2-) I=0

PRODUCTION AND FORMATION EXPERIMENTS AGREE QUITE WELL
WITH EACH OTHER ,THEREFORE. THEY HAVE NOT BEEN SEPARATE
FOR THIS PARTICLE
  A POSSIBLE EXCEPTION TO ABOVE IS THE LAM PI PI
MODE.  BOTH CHAN 72 AND MAST 73 (FORMATION) AGREE
THAT IT IS PREDOMINANTLY Y*1(1385) PI.  HOWEVER,
THEY DISAGREE BY A FACTOR OF 2 AS TO THE CONTRIBUTION
OF Y*0(1520) TO THE OVERALL LAM PI PI CROSS SECTION.
BURKHARDT 71 (PRODUCTION), WITH MUCH LESS STATISTICS,
FIND A MUCH LOWER BRANCHING RATIO.

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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            . . . . . . . . . .
M   AVG     1517.85     0.95     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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            . . . . . . . . . .
W   AVG       15.5      1.3      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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 SIGMA0 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

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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 5          P 6
 P 1 .4502+-.0089
 P 2   -.7405    .4115+-.0092
 P 3   -.2227      -.3403   .1004+-.0054
 P 4   -.0689      -.0647     -.0324   .0080+-.0014
 P 5   -.1739      -.1633     -.0819     -.0095   .0199+-.0035
 P 6   -.0738      -.0693     -.0347     -.0040     -.0102   .0100+-.0015

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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          . . . . . . . . . .
R1  AVG       0.851     0.064    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R1  FIT       0.914     0.036   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
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Data Card Listings

For notation, see key at front of Listings.

Baryons

Λ(1520), Λ(1670)

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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          . . . . . . . . .
R2  AVG       0.202     0.021   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  FIT       0.223     0.014  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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  FIT       4.10      0.27   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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       0.80      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       1.99      0.35   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          . . . . . . . . .
R6  AVG       0.439     0.033   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
R6  FIT       0.4502    0.0089 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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          . . . . . . . . .
R7  AVG       0.424     0.015   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R7  FIT       0.4115    0.0092 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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          . . . . . . . . .
R8  FIT       0.0100    0.0015 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R9     Y*0(1520) INTO (Y*1(1385) PI)/(LAM PI PI)          (P7)/(P3)
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   B  CENTRAL BIN(1514-1524) GIVES .74+-.10 -- OTHER BINS LOWER BY 2-5SIG
R9   C  ONLY 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 = 3.0)

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           0.11      0.01            MAST      73 IPWA  0 K-P TO LAM.PIPI   1/73*
R11         . . . . . . . . .
R11 AVG       0.1080    0.0089  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R11 FIT       0.1004    0.0054 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                         REFERENCES FOR Y*0(1520)

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 106        +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

                              PAPERS NOT REFERRED TO IN DATA CARDS

BERLEY   70 PR D1 1996        +YAMIN,KOFLER,MANN,MEISNER+ (BNL,MASA,YALE)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.
                  (SEE THE NOTE FOR THE Y*0(1330)).

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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    A           THE MULTICHANNEL ANALYSIS INCLUDES ELASTIC AND SIGMA PI .  10/69
M    N   THE APPARENT DISCREPANCY BETWEEN THESE RESULTS IS PROBABLY NOT
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*
                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

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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    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
          SEE THE NOTES ACCOMPANYING MASSES QUOTED

R3      Y*0(1670) FROM KBAR N TO SIGMA PI                  SQRT(P1*P3)
R3            (-0.25)    (0.06)        ARMENT-2  68 HBC   0 OLD DATA
R3             -0.27                   ARMENT-3  69 HBC   0                   9/69
R3             -0.30     (0.03)        ARMENT-4  69 HBC   0 NEW DATA          9/69
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

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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

                              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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Λ(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    (1697.0)    (2.0)          CONFORTO  68 HBC   0 ELASTIC, CH EXCH 11/68
M     A    1691.0     (2.0)          ARMENT-4  69 HBC   0 ELAS,CH EXC.ED    9/69
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    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   ANALYSIS INCLUDES OLD AND NEW DATA OF CHS COLLAB.  .43-.8 GEV/C     10/69
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.

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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*
            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                          1384+ 139

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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   N  EFFECT IS AT END OF REGION ANALYZED. THIS COULD AFFECT VALUE OF X1.
R1       FROM ALL ABOVE WE ESTIMATE  X=0.20                                 3/72

R2     Y*0(1690) FROM KBAR N TO SIGMA PI                 SQRT(P1*P2)
R2         (-0.33)   (0.02)          ARMENT-3  68 HBC   0 OLD DATA         11/68
R2          -0.36    (0.02)          ARMENT-4  69 HBC   0 NEW DATA          9/69
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*

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

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                           REFERENCES FOR Y*0(1690)

DAVIES   67 PRL 18 62          +DOWELL, +                  (BIRM,CAVE,RHEL) I
    REPLACED BY BUGG 68.
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
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

                               PAPERS NOT REFERRED TO IN DATA CARDS

PREVOST  71  AMSTERDAM CONF    + CHS COLLABORATION         (CERN+HEID+SACL)

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Λ(1750) P_{01}

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77  Y*0(1750, JP=1/2+) I=0

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 BEHAVIOR OF THE P01 AMPLITUDE WHEN IT
    WAS PARAMETRIZED AS A TWO-STRAIGHT-LINE BACKGROUND.  WHEN IT WAS RE-
    PARAMETRIZED AS A RESONANCE SUPERIMPOSED ON A ONE-STRAIGHT-LINE BACK-
    GROUND, A BROAD RESONANCE RESULTED (ARMENTEROS 68).  A REANALYSIS OF
    ESSENTIALLY THE SAME DATA, BUT THIS TIME WITH THE P01 AMPLITUDE UNCON-
    STRAINED, SUGGESTED A MUCH NARROWER RESONANCE AT HIGHER ENERGY (ARMEN-
    TEROS 70).
       A WIDER AND MORE ELASTIC P01 RESONANCE AT ABOUT THE SAME MASS IS
    SUGGESTED BY THE ANALYSIS OF BAILEY 69.  THIS USES CONSIDERABLY LESS
    DATA THAN THE ARMENTEROS ANALYSES. FOR THIS REASON WE DO NOT QUOTE ANY
    PARAMETERS FOR THE OTHER PARTIAL WAVES OBTAINED IN THIS ANALYSIS.
       ARMENTEROS 70, GALTIERI 70, AND KIM 71 PRESENT EVIDENCE FOR A
    P01 STATE IN THE SIGMA PI CHANNEL. IN ADDITION THE ANALYSES OF KIM 71
    AND LANGBEIN 72 INDICATE A SECOND POSSIBLE P01 STATE.WE TENTATIVELY
    LIST THESE EFFECTS TOGETHER.

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                 77  Y*0(1750) MASS (MEV)

M   O     (1745.0)                   ARMENTERO 68 HBC   0 ELASTIC, CH EXCH 11/68
M         (1740.0)                   BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
M         (1800.0)                   ARMENTERO 70 HBC   0 ELASTIC, CH EX    6/70
M         (1750.0)                   ARMENTERO 70 HBC   0 SIGMA PI          6/70
M   N     (1690.0)   (10.0)          GALTIERI  70 HBC   0 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   1     (1570.)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
M  A       1620.0    (10.0)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72*
M  B       1780.0    (20.0)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72*
M  A AND B CORRESPOND TO 2 DIFFERENT RESONANCES IN P01
M   1  POSSIBLE EFFECT IN SIGMA PI AND KBAR N CHANNELS.
M   O  OLD ANALYSIS, USING OLD DATA.

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                 77  Y*0(1750) WIDTH (MEV)

W          (147.0)                   ARMENTERO 68 HBC   0
W          (300.0)                   BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
W           (30.0)                   ARMENTERO 70 HBC   0 ELASTIC, CH EX    6/70
W           (70.0)                   ARMENTERO 70 HBC   0 SIGMA PI          6/70
W   N       (22.0)                   GALTIERI  70 HBC   0 SIG PI,EDPWA      7/70
W           (35.)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
W   1       (50.)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
W  A         60.0    (10.0)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72*
W  B        120.0    (10.0)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72*
        SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                 77  Y*0(1750) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     Y*0(1750) INTO KBAR N                                 497+ 939
P2     Y*0(1750) INTO SIGMA PI                              1197+ 139

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                 77  Y*0(1750) BRANCHING RATIOS


R1     Y*0(1750) INTO (KBAR N)/TOTAL                     (P1)
R1          (0.4)                    ARMENTERO 68 DPWA  0 ELASTIC, CH EXCH 11/68
R1          (0.55)                   BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
R1          (0.15)                   ARMENTERO 70 DPWA  0 ELASTIC, CH EXCH 10/70
R1          (0.30)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1 A         0.25    (0.15)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72*
R1 B         0.36    (0.05)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72*

R2     Y*0(1750) FROM KBAR N INTO SIGMA PI               SQRT(P1*P2)
R2          (+0.20)                  ARMENTERO 70 DPWA  0 K-P TO SIGMA PI   6/70
R2  N       (-0.13)   (0.03)         GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
R2          (0.17)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2 A         0.28    (0.09)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72*
R2 B         0.01  OR LESS           LANGBEIN  72 IPWA    MULTICHANNEL     12/72*
        SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                           REFERENCES FOR Y*0(1750)

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

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Data Card Listings

For notation, see key at front of Listings.

Baryons

Λ(1815), Λ(1830)

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.

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                  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    N   ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED   1/71

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                  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*
         SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                  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 Y*1(1385) PI                      1384+ 139
P4     Y*0(1815) INTO SIGMA PI PI                       1192+ 139+ 139
P5     Y*0(1815) INTO LAMBDA PI PI                      1115+ 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 .6050+-.0243
 P 2   -.5445   .1138+-.0084
 P 3   0.         0.       .2000+-.0500
 P 4   -.3638     .0892      -.9224   .0812+-.0542


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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           . . . . . . . . . .
R1  AVG      0.605      0.027   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.8)
R1  FIT      0.605      0.024  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 3.4)

R2      Y*0(1815) FROM KBAR N INTO SIGMA PI               SQRT(P1*P2)
R2           0.27       0.01           ARMENT-1  67 DPWA  0 K-P TO SIGMA PI   8/67
R2           0.23       0.025          BELL      67 DPWA  0 K-P 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           . . . . . . . . . .
R2  AVG MOD  0.2634     0.0081  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  FIT      0.2624     0.0081 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      Y*0(1815) FROM KBAR N INTO Y*1(1385) PI           SQRT(P1*P3)
R3  A       (0.3)      (0.05)          ARMENT-2  67 HBC   0 K-P TO LAM P+ P+
R3           . . . . . . . . . .
R3  FIT      0.348      0.044  FROM FIT

R4      Y*0(1815) INTO (Y*1(1385) PI)/TOTAL               (P3)
R4           0.20       0.05           BIRGE     65 HBC   0 K-P TO LAM PI PI  7/66
R4           . . . . . . . . . .
R4  FIT      0.200      0.050  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5      Y*0(1815) INTO (SIGMA PI PI)/TOTAL                (P4)
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      0.081      0.054  FROM FIT

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                              REFERENCES FOR Y*0(1815)

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

                              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 APPEARS TO BE 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    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*
        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                      1384+ 139

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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*

R2      Y*0(1830) FROM KBAR N INTO SIGMA PI               SQRT(P1*P2)
R2           0.15      (0.02)          ARMENTERO 67 DPWA  0 K-P TO SIGMA PI   8/67
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*

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Baryons

Λ(1830), Λ(1860), Λ(1870), Λ(2010)

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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 CONFORTO 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

                                  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.

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                        60  Y*0(1860) MASS (MEV)

M   A  F07 1864.0      2.0            ARMENTERO 68 DWPA  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      P03 1870.0      6.0            BRICMAN1  70 DPWA  0 SIGTOT,ELAS,CHEX  1/71
M   .N P03 1883.0     10.0            CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
M   1  P03 1710.                      KIM       71 DPWA    K-MATRIX ANAL.    3/71
M           1850.0   (20.0)           LANGBEIN  72 IPWA    MULTICHANNEL     12/72*
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.

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                        60  Y*0(1860) WIDTH (MEV)

W   A  F07    39.0      7.0            ARMENTERO 68 DWPA  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      P03    37.0     10.0            BRICMAN1  70 DPWA  0 SIGTOT,ELAS,CHEX  1/71
W    N P03    80.0     20.0            CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
W   1  P03    20.                      KIM       71 DPWA    K-MATRIX ANAL.    3/71
W            125.0    (20.0)           LANGBEIN  72 IPWA    MULTICHANNEL     12/72*
        SEE THE NOTES ACCOMPANYING MASSES QUOTED

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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

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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     P03     0.14      0.02          BRICMAN1  70 DPWA  0 SIGTOT,ELAS,CHEX  1/71
R1   N P03     0.25      0.03          CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
R1             0.37     (0.05)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72*
        SEE THE NOTES ACCOMPANYING MASSES QUOTED

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).

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                                  REFERENCES FOR Y*0(1860)

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

                                  PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 67 NP B3 592             ARMENTEROS, F-LUZZI, + (CERN,HEIDEL,SACLAY)IJP
    REPLACED BY ARMENTEROS 68 AND CONFORTO 68.
CONFORTO 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)


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Λ(1870) → S'''_{01}

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                        36  Y*0(1870, JP=1/2-) I=0

                        THE S01 AMPLITUDE SHOWS A SECOND RESONANCE BEHAVIOR AT
                        ABOUT 1800 MEV IN 3 ANALYSES.  THE ELASTICITY OF
                        KIM 71 IS SURPRISINGLY LARGE.

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                        36  Y*0(1870) 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*

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                        36  Y*0(1870) 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*

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                        36  Y*0(1870) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      Y*0(1870) INTO KBAR N                               497+ 939
P2      Y*0(1870) INTO SIGMA PI                            1197+ 139

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                        36  Y*0(1870) BRANCHING RATIOS

R1      Y*0(1870) 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*

R2      Y*0(1870) FROM KBAR N TO SIGMA PI                SQRT(P1*P2)
R2           (0.24)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
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                                 REFERENCES FOR Y*0(1870)
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

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Λ(2010) → D'''_{03}

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                        89  Y*0(2010, JP=3/2-) I=0

                        SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

                        SUCH A RESONANCE IS SUGGESTED BY ONLY TWO
                        PARTIAL-WAVE ANALYSES ACROSS THIS REGION.  UNTIL THERE
                        IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN
                        BARYON TABLE.

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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          (1971.0)                    BRANDSTE  72 DPWA    K-P TO LAM.OMEGA  1/73*

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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           (180.0)                    BRANDSTE  72 DPWA    K-P TO LAM.OMEGA  1/73*

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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+ 783

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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           (0.254)                   BRANDSTE  72 DPWA                      1/73*

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                                 REFERENCES FOR Y*0(2010)

GALTIERI 70 DUKE CONF 173        A BARBARO-GALTIERI                    (LRL)IJP
BRANDSTE 72 NP B39 13            BRANDSTETTER,BUTTERWORTH,+ (RHEL+CDEF+SACL)

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Data Card Listings

For notation, see key at front of Listings.

Baryons

Λ(2020), Λ(2100), Λ(2110)

Λ(2020)

27 Y*0(2020, JP=7/2+) I=0 F_{07}

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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.

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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

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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

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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

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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

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

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                         REFERENCES FOR Y*0(2020)

GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                 (LRL)IJP
LITCHFIE 71 NP  B30 125       LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP

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Λ(2100)

41 Y*0(2100, JP=7/2-) I=0 G_{07}

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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 2100 MEV ARE
   GIVEN IN THE NEXT ENTRY.  EVENTUALLY THE PARTIAL-WAVE ANALYSES SHOULD
   GIVE THE BEST RESULTS, AS THEY ISOLATE THE G07 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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                   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          (2113.0)                  BRANDSTE  72 DPWA    K-P TO LAM.OMEGA  1/73*
M           2092.0    (12.0)         KANE      72 DPWA  0 K-P TO PI SIG    10/71
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

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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  0 K-P TO XI K      10/69
W           140.0     (15.0)         BERTHON1  70 DPWA  0 K-P TO SIGMA PI  10/70
W            60.0     (25.0)         GALTIERI  70 DPWA  0 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          (208.0)                   BRANDSTE  72 DPWA    K-P TO LAM.OMEGA  1/73*
W           144.0     (26.0)         KANE      72 DPWA  0 K-P TO PI SIG    10/71
          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+ 783

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                   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  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  0 K-P TO SIGMA PI  10/70
R2          +0.06     (0.03)         GALTIERI  70 DPWA  0 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  0 K-P TO PI SIG    10/71

R3      Y*0(2100) FROM KBAR N TO XI K                     SQRT(P1*P3)
R3           (0.05)                  TRIPP     67 RVUE  0 K-P TO XI K       8/67
R3  B        (0.09)   (0.01)         BURGUN    68 DPWA  0 K-P TO XI K      10/69
R3           (0.003)                 MULLER    69 DPWA  0                   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           (0.053)                 BRANDSTE  72 DPWA                      1/73*
          SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                         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

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Λ(2110)

35 Y*0(2110, JP=5/2) I=0 F''_{05} or D''_{05}

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          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.

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                   35  Y*0(2110) MASS (MEV)

M          (2110.)    (10.)          BERTHON1  70 DPWA -  K- P TO SIG PI     1/71
M          (2140.)    (40.)          LITCHFIE  71 DPWA    K-P TO KBAR N     10/71
M       F05 2034.0                   BRANDSTE  72 DPWA    K-P TO LAM.OMEGA   1/73*
M    A    (2141.0)    (6.0)          KANE      72 DPWA  0 K-P TO PI SIG     10/71
M    A  RESONANCE OUTSIDE RANGE OF DATA.

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                   35  Y*0(2110) WIDTH (MEV)

W           (185.)    (30.)          BERTHON1  70 DPWA -  K- P TO SIG PI     1/71
W           (120.)    (40.)          LITCHFIE  71 DPWA    K-P TO KBAR N     10/71
W           (154.0)                  BRANDSTE  72 DPWA    K-P TO LAM.OMEGA   1/73*
W    A      (504.0)   (10.0)         KANE      72 DPWA  0 K-P TO PI SIG     10/71

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                   35  Y*0(2110) PARTIAL DECAY MODES

                                                          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+ 783

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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  0 K-P TO PI SIG     10/71

R2      Y*0(2110) INTO (KBAR N)/TOTAL                    (P1)
R2            (0.14)    (0.04)       LITCHFIE  71 DPWA    K-P TO KBAR N     10/71

R3      Y*0(2110) FROM KBAR N INTO LAMBDA OMEGA          SQRT(P1*P3)
R3            (0.152)                BRANDSTE  72 DPWA                       1/73*

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                         REFERENCES FOR Y*0(2110)

BERTHON1 70 NP B24 417        +VRANA,BUTTERWORTH,+      (CDEF,RHEL,SACLAY)IJP
LITCHFIE 71 NP  B30 125       LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
BRANDSTE 72 NP B39 13         BRANDSTETTER,BUTTERWORTH,+ (RHEL+CDEF+SACL)
KANE     72 PR D5 1583        D F KANE                            (LBL)IJP

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Λ(2100) BUMPS

25 Y*0(2100, JP=) I=0 PRODUCTION EXPERIMENTS

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            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 ESTAB-
   LISHED OTHER RESONANCES IN THIS REGION.

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                    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

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                    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

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                    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+ 783

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                    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

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                              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.

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Λ(2350) BUMPS

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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.
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                    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

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                    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

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                    42  Y*0(2350) PARTIAL DECAY MODES (PROD. EXP.)

                                                                  DECAY MASSES
P1      Y*0(2350) INTO KBAR N                                  497+ 939

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                    42  Y*0(2350) BRANCHING RATIOS (PROD. EXP.)

R1      Y*0(2350) INTO (KBAR N)/TOTAL                        (P1)
R1         J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1            (0.57)                  BUGG        68 CNTR    K-P, D TOTAL      6/68
R1             1.1       0.25         BRICMAN     70 CNTR  0 TOTAL AND CH EX   6/70
R1            (1.0)                   COOL        70 CNTR    K-P, D TOTAL     10/70

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                              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)

                              PAPERS NOT REFERRED 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

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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.

****** ********* ********* ********* ********* ********* ********* ********

                              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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Σ⁺

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19  SIGMA+ (1189, JP=1/2+) I=1

SEE STABLE PARTICLE DATA CARD LISTINGS

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****** ********* ********* ********* ********* ********* ********* ********
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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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****** ********* ********* ********* ********* ********* ********* ********
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Σ⁰

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21  SIGMAO (1193, JP=1/2+) I=1

SEE STABLE PARTICLE DATA CARD LISTINGS

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****** ********* ********* ********* ********* ********* ********* ********
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Σ(1385) **P'_{13}**

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43  Y*1(1385, JP=3/2+) I=1

 FOR DISCUSSION OF INCONSISTENCY OF ERRORS AND OUR
 MODIFICATIONS, SEE NOTE ON K*(892)

 FOR THE TABLES WE USE ONLY THE UNSTARRED DATA, WHICH
 ATTEMPTS TO OBTAIN THE SEPARATE CHARGE-STATE MASSES AN
 WIDTHS.  SEE HOWEVER THE IDEOGRAMS INSERTED IN LISTING
THESE INDICATE SERIOUS SYSTEMATICS, PERHAPS ARISING FROM INTERFERENCE E
FECTS THAT CHANGE WITH PRODUCTION MECHANISM AND BEAM MOMENTUM.
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                    43  Y*1(1385) MASS (MEV)

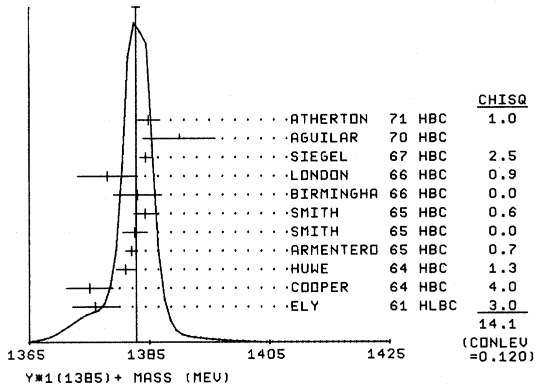
M       141(1384.0)                   ALSTON      60 HBC  +- K-P 1.15 BEV/C
M          (1385.0)                   BERGE       61 HBC  +- K-P .4-.85 BEV/C
M        38(1384.0)                   MARTIN      61 HBC  +0 K20 P .98 BEV/C
M          (1392.0)    (7.0)          COLLEY      62 HLBC -0 PI- PRP 2. 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
MO      106(1381.0)    (4.0)          CURTIS      63 OSPK  0 PI-P 1.5 BEV/C
```

Data Card Listings

For notation, see key at front of Listings.

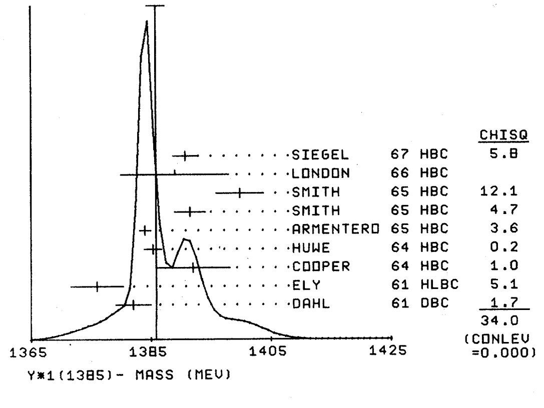
```
M+    E 154 1376.0      3.9                ELY       61 HLBC +  K-P 1.11 BEV/C
M+    E           ERROR OF 3.0 ENLARGED TO 3.9 BY US,BECAUSE LT STATIST.ERR. 10/69
M+      170 1375.0      3.9                COOPER    64 HBC  +  K-P 1.45 BEV/C
M+      859 1381.0      1.6                HUWE      64 HBC  +  K-P 1.22 BEV/C
M+      750 1382.0      1.0                ARMENTERO 65 HBC  +  K-P .9-1.2 BEV/C
M+    S 250 1382.6      2.1                SMITH     65 HBC  +  K-P 1.95 BEV/C    9/66
M+    S 250 1384.3      1.9                SMITH     65 HBC  +  K-P 1.8 BEV/C     9/66
M+    S           ERROR OF 1.4 ENLARGED TO 2.1 BY US,BECAUSE <  STATIST.ER.  10/69
M+    S           ERROR OF 1.1 ENLARGED TO 1.9 BY US,BECAUSE <  STATIST.ER.  10/69
M+    B  40 1383.0      4.0                BIRMINGHA 66 HBC  +  K-P 3.5           9/67
M+    B           ERROR OF 2.0 ENLARGED TO 4.0 BY US,BECAUSE <  STATIST.ERR. 10/69
M+          1378.0      5.0                LONDON    66 HBC  +  K-P 2.24 BEV/C    7/66
M+     1260 1384.4      1.0                SIEGEL    67 HBC  +  K-P AT 2.1 GEV/C 10/69
M+          1390.0      6.0                AGUILAR   70 HBC  +  K-P 4 GEV/SIG.PI  5/70
M+          1384.8      2.0                ATHERTON  71 HBC      LAM PI+ + C.C.  10/71
M+          . . . . . . . . .
M+   AVG    1382.81     0.68    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                        (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 1382.81 ± 0.68
ERROR SCALED BY 1.3



```
M-       93 1382.0      3.0                DAHL      61 DBC  -  K-D 0.45 BEV/C
M-    E 224 1376.0      4.4                ELY       61 HLBC -
M-    E           ERROR OF 3.0 ENLARGED TO 4.4 BY US,BECAUSE <  STATIST.ERR. 10/69
M-      200 1392.0      6.2                COOPER    64 HBC  -
M-     1086 1385.3      1.5                HUWE      64 HBC  -
M-     1380 1384.0      1.0                ARMENTERO 65 HBC  -
M-    S 120 1391.5      2.6                SMITH     65 HBC  -  K-P 1.8 BEV/C     9/66
M-    S  58 1399.8      4.0                SMITH     65 HBC  -  K-P 1.95 BEV/C    9/66
M-    S           ERROR OF 1.8 ENLARGED TO 2.6 BY US,BECAUSE <  STATIST.ER.  10/69
M-    S           ERROR OF 1.4 ENLARGED TO 4.0 BY US,BECAUSE <  STATIST.ER.  10/69
M-          1389.0      9.0                LONDON    66 HBC  -                    7/66
M-      370 1390.7      2.0                SIEGEL    67 HBC  -  K-P AT 2.1 GEV/C 10/69
M-          . . . . . . . . .
M-   AVG    1385.9      1.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
                        (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 1385.9 ± 1.5
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                        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     REDUNDANT WITH DATA IN MASS LISTING.

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                     43  Y*1(1385) WIDTH (MEV)

W            (64.0)                       ALSTON    60 HBC  +-
W            (40.0)                       BERGE     61 HBC  +-
W            (20.0)  OR LESS              MARTIN    61 HBC  +0
W            (80.0)   (10.0)              COLLEY    62 HLBC -0
W            (30.0)    (9.0)              CURTIS    63 OSPK  0
W            (26.0)    (5.0)              BALTAY    65 HBC  +-                     7/66
W            (38.0)    (9.0)              MUSGRAVE  65 HBC  +-0                    7/66

W+            48.0      8.0               ELY       61 HLBC +
W+            51.0     10.0               COOPER    64 HBC  +
W+            46.5      3.0               HUWE      64 HBC  +
W+            32.0      3.0               ARMENTERO 65 HBC  +
W+            30.3      3.1               SMITH     65 HBC  +  K-P 1.8 BEV/C       9/66
W+            33.1      3.8               SMITH     65 HBC  +  K-P 1.95 BEV/C      9/66
W+       40   25.0      6.0               BIRMINGHA 66 HBC  +  K-P 3.5             9/67
W+     1260   36.0      3.0               SIEGEL    67 HBC     K-P AT 2.1 GEV/C   10/69
W+            33.      12.0               AGUILAR   70 HBC  +  K-P 4 GEV/SIG.PI    5/70
W+ T     40   20.       4.                ATHERTON  71 HBC     LAM PI+ + C.C.     10/71
W+ T     FIT B.W. + PHASE SPACE BCKGRD
W+ R     40   35.       5.                ATHERTON  71 HBC     LAM PI+ + C.C.     10/71
W+ R     FIT B.W. AND NO BCKGRD
W+         . . . . . . . . .
W+  AVG       34.4      2.4      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
                        (SEE IDEOGRAM BELOW )
```
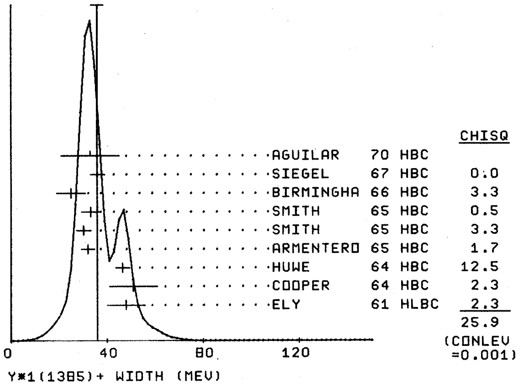
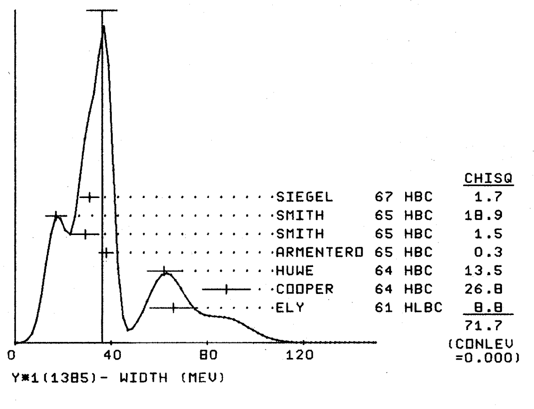

WEIGHTED AVERAGE = 35.9 ± 2.6
ERROR SCALED BY 1.9



```
W-            (40.0)                      DAHL      61 DBC  -
W-             66.0     10.0              ELY       61 HLBC -
W-             88.0     10.0              COOPER    64 HBC  -
W-             62.0      7.0              HUWE      64 HBC  -
W-             38.0      3.0              ARMENTERO 65 HBC  -
W-             29.2      5.7              SMITH     65 HBC  -  K-P 1.80 BEV/C      9/66
W-             17.1      4.4              SMITH     65 HBC  -  K-P 1.95 BEV/C      9/66
W-       370   31.0      4.0              SIEGEL    67 HBC     K-P AT 2.1 GEV/C   10/69
W-          . . . . . . . . .
W-   AVG       36.3      6.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.5)
                        (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 36.3 ± 6.3
ERROR SCALED BY 3.5



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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

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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  +-0
R1            0.09     0.04          HUWE      64 HBC  +-
R1            0.163    0.035         ARMENTERO 65 HBC  +-                   7/66
R1            0.08     0.06          LONDON    66 HBC  +                    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     K-N 1.5 GEV PROD 10/71
R1         . . . . . . . . . .
R1   AVG      0.126    0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
                       (SEE IDEOGRAM BELOW )
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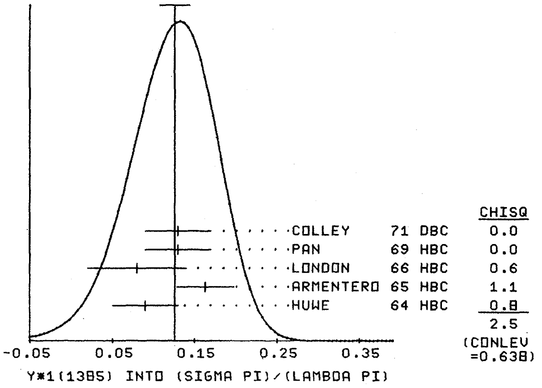
WEIGHTED AVERAGE = 0.126 ± 0.018
ERROR SCALED BY 1.0



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R2      Y*1(1385) INTO LAMBDA GAMMA                        (P3)
R2        1   (0.17)   (0.17)        MEISNER   72 HBC     1 EVENT ONLY       1/73*

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                                     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., OXFORDYRUTHERFORD
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)
MEISNER  72 NC 12A 62            G MEISNER               (U NC GREENSBORO+LBL)

          QUANTUM NUMBER DETERMINATIONS 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

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Σ(1440) BUMPS

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80  Y*1(1440, JP=    ) I=1        PRODUCTION EXPERIMENTS

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

CLINE 68 FIND A NARROW PEAK AT 1440 MEV (JUST ABOVE
THE KBAR N THRESHOLD) IN THE LAMBDA PI INVARIANT MASS
FOR K- D TO LAMBDA PI- P EVENTS.  THEY DISCUSS ALTER-
NATE INTERPRETATIONS -- THAT IT IS A RESONANCE OR A KINEMATIC EFFECT.
IN CLINE 68 THE K- BEAM MOMENTUM IS 0.4 GEV/C.  IN A STUDY OF THE SAME
REACTION WITH A MOMENTUM OF 1.1 GEV/C, ALEXANDER 69 FIND NO PEAK.  IN
ADDITION, THEY ARE ABLE TO EXPLAIN THE RESULTS OF BOTH EXPERIMENTS
WITHOUT INVOKING A NEW RESONANCE. A REANALYSIS OF THE CLINE 68
DATA MADE BY BUNNEL 70 SHOW AGREEMENT OF THE DATA WITH THE
ALEXANDER 69 INTERPERTATION.

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                         REFERENCES FOR Y*1(1440) (PROD. EXP.)

CLINE    68 PRL 21 1372      D CLINE, R LAUMANN, J MAPP      (WISCONSIN) I
ALEXANDE 69 PRL 22 483       ALEXANDER, HALL, JEW, +      (LRL,RIVERSIDE)
BUNNELL  70 LNC 3 224        +CLINE,LAUMANN,MAPP  +       (NWES+WISC+ANL)

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Σ(1480) BUMPS

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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 POS-
SIBLE 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.

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                 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        . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                 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        . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                 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

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                 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

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                         REFERENCES FOR Y*1(1480) (PROD. EXP.)

PAN        70 PR D2, 49          +FORMAN,KO,HAGOPIAN,SELOVE            (PENN)

                         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

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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. A good review of the production experiments has been recently given by MILLER 70. We summarize here the situation.

Formation Experiments. Several partial-wave analyses have found evidence for one or two fairly narrow ($\Gamma \sim 50$ MeV) $I = 1$, $J = 1/2$ states within ~ 50 MeV of the effect seen in production. It is not clear at present how many such states really exist. No one has reported a strong coupling of any of these states to $\overline{K}N$, but there is much disagreement about branching ratios into $\Lambda\pi$ and $\Sigma\pi$. We summarize below the results of several recent partial-wave analyses (see the note on Y^*'s for a discussion of the methods of analysis).

S_{11}: Both KIM 71 and LANGBEIN 72 report an S_{11} state near 1620 MeV with $\Gamma \sim 50$ MeV, but KIM 71 finds $\Lambda\pi$ to be the dominant two-body decay mode while LANGBEIN 72 finds the $\Sigma\pi$ mode dominant. ARMENTEROS 70 report no S_{11} state in any channel in this mass region. VAN HORN 72 finds a 66-MeV -wide S_{11} state at 1697 MeV in his energy-dependent fits to the $\Lambda\pi$ channel, and a 50-MeV-wide state at 1655 MeV in five out of seven of his Barrelet ambiguous solutions.

P_{11}: A 50-MeV-wide P_{11} state in the 1500-1600 MeV mass region of the $\Sigma\pi$ channel was reported by ARMENTEROS 70 with no corresponding effect in $\Lambda\pi$ and $\bar{K}N$. KIM 71 claims a P_{11} state at 1670 MeV with Γ = 50 MeV, a dominant $\Sigma\pi$ two-body decay mode, and vanishing coupling to $\Lambda\pi$. LANGBEIN 72 reports no P_{11} resonance. VAN HORN 72 saw a very broad, Γ = 230 MeV, P_{11} resonance at 1668 MeV in his energy-dependent fits to the $\Lambda\pi$ channel, but a fairly narrow, Γ = 60 MeV, resonance at about the same mass in all of his Barrelet ambiguous solutions.

Production experiments. Here the evidence is only in the $\Lambda\pi$ channel. The BNL-CCNY collaboration, with increased data, CRENNELL 69, still claim the effect in the $\Lambda\pi$ channel (no evidence seen in $\bar{K}N$ or $\bar{K}N\pi$). SABRE 70 studied the same reaction at 3.0 GeV/c with comparable statistics and do not see any evidence for it in the $\Lambda\pi$ channel; on the contrary, they believe it to be a spurious peak resulting from misidentified Σ^0 from the production of Σ(1670) decaying into $\Sigma^0\pi^+$. CRENNELL 69 give counter arguments to show that this is not the case in their data and the controversy goes on. AMMANN 70 studied the same reaction at 4.5 GeV/c and report a state at 1640 MeV, again decaying only into $\Lambda\pi$ (no evidence seen in $\Sigma\pi$ or $\bar{K}N$ channels). The closeness of this mass to 1670 MeV is suggestive that this effect may be related to what goes on in that region (see discussion below).

In conclusion, for Σ(1620) we have to wait for more data and for a complete understanding of the entire mass region 1600 to 1700 MeV. The hope is that the determination of quantum numbers for each of these effects for each decay mode may eventually clarify the situation.

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 VANHORN72 IS INTERMEDIATE IN
 MASS BETWEEN THE SIGMA(1620) AND SIGMA(1750).  WE TENTATIVELY LIST IT
 UNDER SIGMA(1750).

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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*

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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*

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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 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*

R3      Y*1(1620) FROM KBAR N TO LAMBDA PI              SQRT(P1*P3)
R3            (0.15)                    KIM        71 DPWA    K-MATRIX ANAL.    3/71

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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

                          PAPERS NOT REFERRED TO IN DATA CARDS

VANHORN  72 LBL-1370(THESIS)                                             /LBL IJP

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Σ(1620) **P'_{11}**

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79  Y*1(1620, JP=1/2+) I=1
SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THE PARTIAL-WAVE ANALYSIS OF K- N TO SIGMA PI BY
ARMENTEROS 70 SUGGESTS SUCH A RESONANCE.  KIM 71 FINDS
A SIGNAL IN BOTH KBAR-N AND SIGMA PI.

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                  79  Y*1(1620) 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          1668.       (.25)            VANHORN    72 DPWA  0 K- P TO LAM PIO  2/73*

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                  79  Y*1(1620) 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           230.     (165.)    (60.)    VANHORN    72 DPWA  0 K- P TO LAM PIO  2/73*

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                  79  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+ 139

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                  79  Y*1(1620) BRANCHING RATIOS

R1      Y*1(1620) 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

R2      Y*1(1620) INTO KBAR N                           (P1)
R2             (0.14)                   KIM        71 DPWA    K-MATRIX ANAL.   3/71
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R3      Y*1(1620) FROM KBAR N TO LAMBDA PI                    SQRT(P1*P3)
R3           (0.0)                      KIM        71 DPWA   K-MATRIX ANAL.    2/73*
R3             .12       (.12)     (.04) VANHORN    72 DPWA  O K- P TO LAM PIO  2/73*

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                                 REFERENCES FOR Y*1(1620)

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
VANHORN  72 LBL-1370(THESIS)                                          /LBL'IJP

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Σ(1620) BUMPS

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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.
      THERE WAS AN INDICATION OF A Y*1(1610) IN AN EARLY PHASE-SHIFT
   ANALYSIS OF K-P TO LAMBDA PI.  HOWEVER MORE DETAILED ANALYSIS OF
   MORE EXTENSIVE DATA BY THE SAME (CERN, HEIDELBERG, SACLAY) GROUP
   FAILED TO CONFIRM THIS RESULT. THEY NOW SEE IT IN THE SIGMA PI
   CHANNEL (SEE PREVIOUS ENTRY). (OLD LAMBDA PI ANALYSIS LISTED AS
   ARMENTEROS 68, NEW ANALYSIS AS ARMENTEROS 70.)

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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  +  KO 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-P 4.5 GEV/C     6/70
M          . . . . . . . . .
M   AVG    1619.4      3.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)

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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-P 4.5 GEV/C      6/70
W          . . . . . . . . .
W   AVG        41.3     12.2    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                 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-P 4.5 GEV/C     6/70

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)

                        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)

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Note on Σ(1670)

Formation experiments show the presence of only one I = 1 state in this energy region with major decay modes into $\overline{K}N$ (7-10%), $\Lambda\pi$ (10-15%), $\Sigma\pi$ (30-50%), $\Sigma\pi\pi$ (5-15%), and some $\Lambda\pi\pi$ (the experimental situation here is unclear). Its quantum numbers are $J^P = 3/2^-$.

Production experiments are more confused. When determined, the most likely quantum numbers are also $3/2^-$[for $\Sigma\pi$ and $\Lambda(1405)\pi$]. The measured branching ratio $R = \Sigma\pi/\Sigma\pi\pi$ changes with the momentum transfer to the proton. This was first observed by EBERHARD 69 who suggested the existence of 2 Y_1^* 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 now been confirmed by AGUILAR-BENITEZ 70 .

The other difficulty comes from the different $\Lambda\pi/\Sigma\pi$ branching ratios reported by the various experiments. Those experiments done with K^- beams below 2 GeV/c (HUWE 64 and BUTTON-SHAFER 68) report values for the $\Lambda\pi/\Sigma\pi$ ratio in agreement with formation experiments; the others report a higher $\Lambda\pi/\Sigma\pi$ ratio. Therefore, 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 still exists. This large branching ratio is the main justification for this hypothesis and needs confirmation. It relies on the separation between $K^-p \rightarrow \Lambda\pi^+\pi^-$ and $K^-p \rightarrow \Sigma^0\pi^+\pi^-$, which is experimentally difficult at high energy. These problems are reviewed by MILLER 70.

Two resonances of the same spin and parity have been hypothesized by EBERHARD 69 as the origin of much of the complexity observed in the 1600 to 1700 MeV region in production experiments. See also the note on Σ(1620).

Σ(1670)

D'_{13}

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         44  Y*1(1670, JP=3/2-) I=1

         SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

         SEE NOTE ABOVE

         WELL ESTABLISHED RESONANCE.  IT HAS BEEN SEEN IN BOTH
         FORMATION AND PRODUCTION EXPERIMENTS.  HOWEVER THE
         BRANCHING RATIOS OBTAINED BY THESE TWO METHODS SHOW
         LARGE INCONSISTENCIES.

   SEE LISTING OF PRODUCTION EXPERIMENTS BELOW

   AS FOR THE QUANTUM NUMBERS, THE ANALYSES OF LAMBDA PI CHANNFL (IN
   FORMATION EXP.) AS WELL AS THE SIGMA PI CHANNEL AGREE ON JP=3/2-.

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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          1659.     (12.)       (5.)      VANHORN   72 DPWA   0 K- P TO LAM PIO    2/73*

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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            32.     (11.)                 VANHORN   72 DPWA   0 K- P TO LAM PIO    2/73*

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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                          1384+ 139
P7      Y*1(1670) INTO Y*0(1405) PI                          1405+ 139

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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*

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           +0.1                       ARMENTER  70HBC      K-P TO LAMB PI     5/70
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            +.09      (.02)           VANHORN   72 DPWA  0 K- P TO LAM PIO    2/73*

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*

R7      Y*1(1670) FROM KBAR N TO Y*1(1385) PI              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

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

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                          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
VANHORN  72 LBL-1370(THESIS)                                         /LBL IJP
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                     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

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            51  Y*1(1670, JP=    ) I=1        PRODUCTION EXPERIMENTS

            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.  BRANCHING RATIOS NOT
            DISENTANGLED YET, WE LIST THEM TOGETHER FOR NOW.

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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         . . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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            51  Y*1(1670) MASS (MEV) (PRCD. 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              SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
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         . . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 3.4)

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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

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            . . . . . . . . . .
R2   AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

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

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

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   A       BETWEEN 2.5 AND 0.24    EBERHARD  69 HBC     K-P AT 2.6 GEV/C  9/69
     A       DEPENDING ON THE PRODUCTION ANGLE

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

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
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Σ(1670), Σ(1690), Σ(1750)

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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

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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)

                              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

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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.
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                    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     N     (1700.0)     (6.0)          SIMS      68 HBC  -  K-N TO LAM PI PI 11/68
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    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    THIS ANALYSIS, WHICH IS DIFFICULT AND REQUIRES SEVERAL ASSUMPTIONS
M       AND SHOWS NO UNAMBIGUOUS Y*1(1690) SIGNAL, SUGGESTS JP=5/2+.  SUCH A
M       Y* WOULD LEAD ALL PREVIOUSLY KNOWN Y* TRAJECTORIES.

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                    58  Y*1(1690) WIDTH (MEV) (PROD. EXP.)

W         30 (100.0)    (35.0)          COLLEY    67 HBC  +                    8/67
W         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         46  (25.0)    (10.0)          BLUMENFEL 69 HBC  +                    9/69
W           (130.0)     (25.0)          MOTT      69 HBC  +                    9/69
                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

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

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)

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

BLUMENFE 69 PL 29B 58         B J BLUMENFELD, G R KALBFLEISCH        (BNL) I
MOTT     69 PR 177 1966       +AMMAR, DAVIS, KROPAC, +(NORTHWEST,ARGONNE) I

                            . PAPERS NOT REFERRED TO IN DATA CARDS

AGUILAR  70 PRL 25 58         AGUILAR-BENITEZ,BARNES,BASSANO+  (BNL+SYRA)

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Σ(1750) **S''_{11}**

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                    57  Y*1(1750, JP=1/2-) I=1

                    SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

                    THERE IS NOW EVIDENCE IN THREE CHANNELS FOR AN S11 RE-
                    SONANCE NEAR THIS ENERGY.  INTERPRETATION OF THE SIGMA
                    ETA THRESHOLD BUMP ON ITS OWN MERITS IS NOT CONCLUSIVE
  (CLINE 67) -- MORE DATA ARE NEEDED.  BUT BY ANALOGY WITH THE SIMILAR
  N ETA AND LAMBDA ETA THRESHOLD EFFECTS, WHICH ARE ALMOST CERTAINLY RE-
  SONANCES, IT SEEMS VERY LIKELY THAT THIS TOO IS A RESONANCE.  SEE THE
  RAPPORTEUR TALKS OF FERRO LUZZI 66 AND MEYER 67 FOR DISCUSSIONS.
     IN THE ENERGY-INDEPENDENT PARTIAL WAVE ANALYSIS OF K- N TO LAMBDA
  PI, THE S11 AMPLITUDE APPEARS TO RESONATE (ARMENTEROS 69).  IN 1968 IT
  APPEARED TO RESONATE NEAR 1650 MEV (ARMENTEROS 68), AND WAS LISTED
  HEREIN AS A SEPARATE STATE.  NOW IT HAS MOVED CLOSE ENOUGH TO THE
  OTHER EFFECTS TO BE TENTATIVELY LISTED WITH THEM, BUT THE SIZE OF THE
  CHANGE IN THE MASS SHOULD BE A HEALTHY WARNING THAT THE PARAMETERS
  GIVEN FOR RESONANCES IN LOWER PARTIAL WAVES FROM SUCH ANALYSES ARE
  SUBJECT TO LARGE CHANGE.  (ARMENTEROS 70, FROM WHICH THE RESONANCE
  PARAMETERS ARE QUOTED, IS A SLIGHT UPDATING OF ARMENTEROS 69.)
     THERE IS WEAKER EVIDENCE FOR THIS RESONANCE IN AN ENERGY-DEPENDENT
  PARTIAL-WAVE ANALYSIS OF ELASTIC AND CHARGE-EXCHANGE SCATTERING (CON-
  FORTO 71).
     KIM 71 IN A MULTICHANNEL ANALYSIS FINDS A SURPRISINGLY LARGE
  ELASTICITY (.8), AND SMALLER AMPLITUDE IN THE LAMBDA PI CHANNEL.
     VANHORN 72 FINDS A STATE SOMEWHAT BELOW THE SIGMA ETA THRESHOLD IN
  AN ANALYSIS OF THE LAMBDA PI CHANNEL.
     IN VIEW OF THESE DISCREPANCIES WE DO NOT QUOTE ANY VALUES FOR
  THE BRANCHING RATIOS.

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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         (1697.)    (20.)     (10.)  VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73*

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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           (66.)    (14.)     (12.)  VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73*

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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

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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*

R2      Y*1(1750) FROM KBAR N INTO SIGMA ETA               SQRT(P1*P2)
R2            SEEN                    CLINE     69 DBC  -  THRESHOLD BUMP    9/69

R3      Y*1(1750) FROM KBAR N INTO LAMBDA PI               SQRT(P1*P3)
R3           (-0.25)                  ARMENTERO 70 IPWA -0 K-N TO LAMBDA PI  6/70
R3            (0.09)                  KIM       71 DPWA    K-MATRIX ANAL.    3/71
R3            (0.30)   (0.05)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72*
R3            (-.13)    (.04)         VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73*

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*

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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
VANHORN  72 LBL-1370(THESIS)                                       /LBL IJP
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                              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)

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45  Y*1(1765, JP=5/2-) I=1
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D_{15}

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            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          1774.      10.            VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73*
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           146.      18.            VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73*
W          . . . . . . . . .
W    AVG    116.0      7.9      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.5)
                           (SEE IDEOGRAM BELOW )
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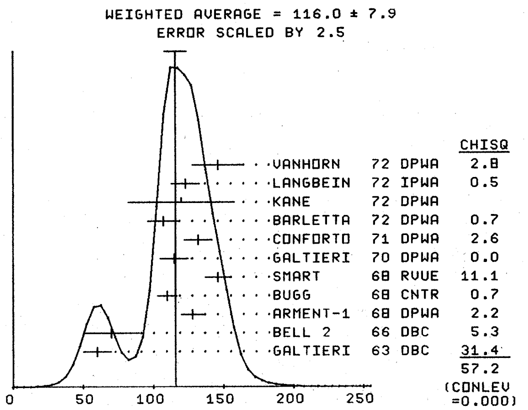

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                  45  Y*1(1765) PARTIAL DECAY MODES

                                                              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                           1384+ 139
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 .4113+-.0169
 P 2    .0885  .1320+-.0168
 P 3    .0540     .0048  .1566+-.0328
 P 4    .1118     .0099     .0060  .1028+-.0375
 P 5   -.1181    -.0104    -.0064    -.0132  .0118+-.0040
 P 6   -.4158    -.3284    -.5764    -.6970    -.0210  .1853+-.0585


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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           . . . . . . . . .
R1  AVG        0.409    0.021   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.3)
R1  FIT        0.411    0.017  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.7)
                       (SEE IDEOGRAM BELOW )
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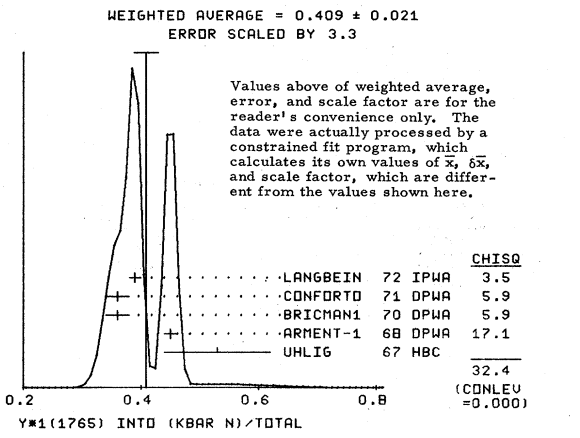

Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\overline{x}$, $\delta\overline{x}$, and scale factor, which are different from the values shown here.

```
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           -.28       .04       .05    VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73*
R2         . . . . . . . . .
R2  AVG MOD  0.245     0.022   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R2  FIT      0.233     0.016  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

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         . . . . . . . . .
R3  AVG      0.298     0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R3  FIT      0.254     0.027  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.1)

R4      Y*1(1765) FROM KBAR N INTO Y*1(1385) PI             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         . . . . . . . . .
R4  FIT      0.206     0.038  FROM FIT

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   8/67
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         . . . . . . . . .
R5  AVG      0.070     0.012   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  FIT      0.070     0.012  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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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         0.321     0.042  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

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         0.381     0.080  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.1)

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         0.250     0.091  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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)

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,CONDON,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 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

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
VANHORN  72 LBL-1370(THESIS)                                           /LBL 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. HARRISON (THESIS)                   (FSU)
PREVOST  71  AMSTERDAM CONF   + CHS COLLABORATION          (CERN+HEID+SACL)

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Σ(1840)

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P''_{13}

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01  Y*1(1840, JP=3/2+) I=1

SEE THE MINI-REVIEWS PRECEDING THE Y*0'S.

FOR THE TIME BEING, WE LIST THESE TWO CLAIMS
TOGETHER.

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                    01  Y*1(1840) MASS (MEV)

M          1840.0    (10.0)             LANGBEIN  72 IPWA    MULTICHANNEL      12/72*
M          1925.     (200.)             VANHORN   72 DPWA  0 K- P TO LAM PIO    2/73*

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                    01  Y*1(1840) WIDTH (MEV)

W           120.0    (10.0)             LANGBEIN  72 IPWA    MULTICHANNEL      12/72*
W            65.     (50.)     (20.)    VANHORN   72 DPWA  0 K- P TO LAM PIO    2/73*

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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*

R2      Y*1(1840) FROM KBAR N INTO SIGMA PI                 SQRT(P1*P2)
R2              0.15     (0.04)             LANGBEIN  72 IPWA    MULTICHANNEL      12/72*

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              +.06      (.04)             VANHORN   72 DPWA  0 K- P TO LAM PIO    2/73*

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                                  REFERENCES FOR Y*1(1840)

LANGBEIN 72 NP B47 477        +WAGNER                                 (MPIM)IJP
VANHORN  72 LBL-1370(THESIS)                                           /LBL IJP

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Σ(1880)

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P''_{11}

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67  Y*1(1880, JP=1/2+) 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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                    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         (1772.0)                     KANE      72 DPWA    K-P TO SIGMA PI   1/73*
M          1985.      50.              VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73*
M          . . . . . . . . .
M   AVG    1925.6     19.9    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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          (80.0)                      KANE      72 DPWA    K-P TO SIGMA PI   1/73*
W           220.     140.              VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73*
W          . . . . . . . . .
W   AVG     185.0     29.9    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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

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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

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             +.05       .07       .02    VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73*
R2          . . . . . . . . .
R2  AVG MOD   0.107      0.017   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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 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)
VANHORN  72 LBL-1370(THESIS)                                         /LBL IJP

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Σ(1915)

F'_{15}

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46  Y*1(1915, JP=5/2+) I=1

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
   (OR AT LEAST ATTEMPT TO -- THE SIGNAL IS WEAK).  THIS MASS REGION IS
   COMPLICATED AND POORLY UNDERSTOOD AND THE PEAKS MAY CONTAIN MORE THAN
   JUST THE Y*1(1915).  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   B      (1985.0)   (21.0)            ISLAM     71 DPWA    KN--PI-SIG       .12/72*
M   B  DISCREPANCY DUE POSSIBLY TO INSUFFICIENT STATISTICS
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.       .15       .20   VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73*
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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                          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   B      (159.0)    (80.0)            ISLAM     71 DPWA    KN--PI-SIG       12/72*
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           102.       18.              VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73*
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

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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

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             -.09      .02            VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73*

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  B         (0.06)   (0.02)           ISLAM     71 DPWA    KN--PI-SIG       12/72*
R3            -0.137   (0.015)          KANE      72 DPWA  0 K-P TO PI SIG    10/71

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                                REFERENCES FOR Y*1(1915)

ARMENTER 67 PL 248 198          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
ISLAM    71 PJSIR 14 305        +COX,COLLEY,HEATHCOTE                 (BIRM) IJP
    PAKISTAN J. SCI. IND. RES.
LITCHFIE 71 NP  B30 125         LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
KANE     72 PR D5 1583          D F KANE                              (LBL)IJP
VANHORN  72 LBL-1370(THESIS)                                          /LBL 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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Σ(1920)
BUMPS

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                          29  Y*1(1920, 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 NOT-COMPLETELY-ESTABLISHED D13 Y*1(1940).

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                          29  Y*1(1920) 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           . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

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                          29  Y*1(1920) 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           . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

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                          29  Y*1(1920) PARTIAL DECAY MODES (PROD. EXP.)

                                                              DECAY MASSES
P1      Y*1(1920) INTO KBAR N                                  497+ 939
P2      Y*1(1920) INTO LAMBDA PI                              1115+ 134
P3      Y*1(1920) INTO SIGMA PI                               1197+ 139

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                          29  Y*1(1920) BRANCHING RATIOS (PROD. EXP.)

R1      Y*1(1920) 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)

R2      Y*1(1920) INTO (KBAR N)/(SIGMA PI)                   (P1)/(P3)
R2            (.37) OR LESS             BARNES    69 HBC   + 1 STAN. DEV.     10/69

R3      Y*1(1920) INTO (LAMBDA PI)/(SIGMA PI)                (P2)/(P3)
R3            (.28) OR LESS             BARNES    69 HBC   + 1 STAN. DEV.     10/69

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                                REFERENCES FOR Y*1(1920) (PROD. EXP.)

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

                                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 ACROSS THIS REGION.  UNTIL THERE
                          IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN
                          BARYON TABLE.  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               1949.      40.      60.     VANHORN   72 DPWA  0 K- P TO LAM PIO    2/73*
M               . . . . . . . . . .
M    AVG        1941.4     19.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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                160.      70.      40.     VANHORN   72 DPWA  0 K- P TO LAM PIO    2/73*
W               . . . . . . . . . .
W    AVG         220.9     26.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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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

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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              -.05      .03      .02   VANHORN    72 DPWA  0 K-P TO LAM PIO     2/73*
R1           . . . . . . . . .
R1   AVG MOD    0.093    0.030    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)

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

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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
VANHORN  72 LBL-1370(THESIS)                                          /LBL 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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                    02  Y*1(2000) MASS (MEV)

M         2004.      40.                 VANHORN    72 DPWA  0 K-P TO LAM PIO     2/73*

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                    02  Y*1(2000) WIDTH (MEV)

W          116.      40.                 VANHORN    72 DPWA  0 K-P TO LAM PIO     2/73*

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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

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                    02  Y*1(2000) BRANCHING RATIOS

R1      Y*1(2000) FROM KBAR N INTO LAMBDA PI             SQRT(P1*P2)
R1                  .07      .02      .01 VANHORN   72 DPWA  0 K-P TO LAM PIO     2/73*

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                         REFERENCES FOR Y*1(2000)

VANHORN  72 LBL-1370(THESIS)                                          /LBL 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         2042.      11.                 VANHORN    72 DPWA  0 K-P TO LAM PIO     2/73*
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         178.       13.                 VANHORN    72 DPWA  0 K-P TO LAM PIO     2/73*
W          . . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

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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

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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   D    DAUM 68 ASSUMES (J+1/2)*P1 VALUE SEEN IN TOTAL CROSS SECTION.
R1          . . . . . . . . .
R1   AVG      0.178     0.018    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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             .20       .01             VANHORN    72 DPWA  0 K-P TO LAM PIO     2/73*
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          . . . . . . . . . .
R3   AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

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

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                         REFERENCES FOR Y*1(2030)

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
VANHORN  72 LBL-1370(THESIS)                                           /LBL IJP

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Σ(2030) BUMPS

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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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Data Card Listings

For notation, see key at front of Listings.

Baryons

Σ(2030), Σ(2070), Σ(2080), Σ(2100), Σ(2250)

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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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                               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 ONLY 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(2070) INTO SIGMA PI                           1197+ 139

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                     34  Y*1(2070) BRANCHING RATIOS

R1      Y*1(2070) 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          (2082.0)    (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

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                     88  Y*1(2080) WIDTH (MEV)

W            (87.0)   (20.0)           COX       70 DPWA -  K- N TO LAM PI     6/70
W           (250.0)   (40.0)           LITCHFIEL 70 DPWA -0 K- N TO LAM PI     6/70

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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

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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

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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.

                     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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                     26  Y*1(2100) MASS (MEV)

M          (2060.0)   (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 PHASE-SHIFT-ANALYSIS RESULTS ARE TOO WEAK TO
                     WARRANT SEPARATING THEM FROM THE PRODUCTION AND CROSS-
                     SECTION EXPERIMENTS. IN AN ANALYSIS OF ELASTIC AND
                     POLARIZATION DATA, DAUM 68 COULD NOT EXCLUDE ANY
    POSSIBILITY FROM JP= 5/2+- TO JP= 11/2+- FOR THIS STATE. BRICMAN 70
    SUGGESTS 712-. VANHORN72 CLAIMS 5/2+.

    LASINSKI 71 SUGGESTS TWO RESONANCES IN THIS REGION USING A POMERON
    + RESONANCES MODEL.

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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    V      2251.      30.      20.    VANHORN   72 DPWA  0 K-P TO LAM PIO    2/73*
M    V     VANHORN72 VALUE FROM A DPWA THAT FINDS JP=5/2+.
M           . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

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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    V       192.      30.             VANHORN   72 DPWA  0 K-P TO LAM PIO    2/73*
W            . . . . . . . . .
W   AVG     169.5     33.4      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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

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Baryons

Data Card Listings

Σ(2250), Σ(2455), Σ(2620), Σ(3000), EX. HYPE.

For notation, see key at front of Listings.

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                  48  Y*1(2250) BRANCHING RATIOS (PROD. EXP.)

R1      Y*1(2250) INTO (KBAR N)/TOTAL                      (P1)
R1         J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1            (0.47)                     BUGG      68 CNTR                       6/68
R1            (0.16)    (0.12)           BRICMAN   70 CNTR  0 TOTAL AND CH EX    6/70
R1            (0.42)                     COOL      70 CNTR    K-P, D TOTAL      10/70

R2      Y*1(2250) FROM KBAR N TO LAMBDA PI                 SQRT(P1*P2)
R2         THE FOLLOWING ASSUMES JP=9/2-. DATA INSUF. FOR DETERM. THIS AMP.
R2           (-0.18)                     GALTIERI  70 DPWA    K-P TO LAMBDA PI 10/70
R2   V          -.16       .03           VANHORN   72 DPWA  0 K-P TO LAM PIO    2/73*
                SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

R3      Y*1(2250) FROM KBAR N TO SIGMA PI                  SQRT(P1*P3)
R3         THE FOLLOWING ASSUMES JP=9/2-. DATA INSUF. FOR DETERM. THIS AMP.
R3           (+0.07)                     GALTIERI  70 DPWA    K-P TO SIGMA PI  10/70

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

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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)
VANHORN  72 LBL-1370(THESIS)                                          /LBL 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

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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)

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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

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                  54  Y*1(2620) WIDTH (MEV) (PROD. EXP.)

W          (175.0)                       ABRAMS    70 CNTR    K-P, D TOTAL      10/70

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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)

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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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EXOTIC HYPERON CROSS SECTION LIMITS

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          THIS IS NOT A COMPLETE LIST. WE WILL TABULATE EXOTICS FROM NOW 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 GAMMA <  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 GAMMA  < 120 MEV- (2.7 GEV/C K-)  7/70

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                                REFERENCES FOR EXOTIC HYPERONS

GALTIERI 68 PRL 21 573          A.BARBARO-GALTIERI,CHADWICK +    (LRL+SLAC)

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Ξ Resonances

The Ξ resonance situation has long been and will probably long remain unsettled. This is because 1) they can only be produced as part of a final state, $K^- + p \rightarrow \Xi^* +$ others, and 2) they are so produced with very small cross sections (<50 μb). Thus the numbers of events available are small, and the analysis is more complicated than if direct formation were possible. Only the Ξ (1530) is really well established. There are at least two Ξ states in the 1800-2000 MeV region and there are indications of several more above 2000 MeV, but the situation is very unclear. We are forced to group together rather disparate observations and await new results. Figures in the listings point out disagreements among various experiments. The table following this note gives our evaluation of the status of the Ξ resonances, based on the meager data available at this time.

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                          STATUS OF XI* RESONANCES
THOSE WITH AN OVERALL STATUS OF *** OR **** ARE INCLUDED IN THE MAIN BARYON
TABLE. THE OTHERS AWAIT CONFIRMATION.

                                STATUS AS SEEN IN --
                      ------------------------------------
                 OVERALL
PARTICLE   LIJ   STATUS     XI PI     LAM K     SIG K     XI* PI   OTHER CHANNELS
------------------------------------------------------------------------------

 XI(1320)  P11    ****                                              WEAK TO LAM PI
 XI(1530)  P13    ****      ****
 XI(1630)           **        **
 XI(1820)          ***       ***       ***        **        ***
 XI(1940)          ***       ***                            ***
 XI(2030)           **                  **        **                3-BODY DECAYS
 XI(2250)            *                                              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.

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Ξ⁻

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               22  XI- (1321, JP=1/2 ) I=1/2

               SEE STABLE PARTICLE DATA CARD LISTINGS

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Ξ⁰

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               23  XIO (1314, JP=1/2 ) I=1/2

               SEE STABLE PARTICLE DATA CARD LISTINGS

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Ξ(1530) **P_{13}**

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               49  XI*1/2(1530, JP=3/2+) I=1/2

               THIS IS THE ONLY REALLY WELL-ESTABLISHED XI*.  THE
               QUANTUM NUMBERS 3/2+ ARE FAVORED 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.

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                  49  XI*1/2(1530) MASS (MEV)

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-     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-        . . . . . . . . .
M-  AVG   1535.22    0.87   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M-  FIT   1535.05    0.62  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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        . . . . . . . . .
MO  AVG   1531.63    0.41   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
MO  FIT   1531.64    0.35  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

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                  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            3.9     1.8            KIRSCH    72 HBC  -0 K- P 2.8 GEV/C    2/72
D         . . . . . . . . .
D   AVG      3.12    0.81   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D   FIT      3.41    0.61  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                  49  XI*1/2(1530) WIDTH (MEV)

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        . . . . . . . . .
WO  AVG      9.07    0.54   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
                            (SEE IDEOGRAM BELOW )
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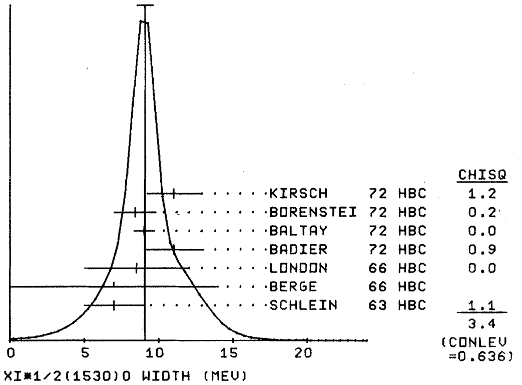
WEIGHTED AVERAGE = 9.07 ± 0.54
ERROR SCALED BY 1.0



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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- PIO,XIO PI-   2/72
W-        . . . . . . . . .
W-  AVG     12.9     4.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

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                  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.

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                               REFERENCES FOR XI*1/2(1530)

PJERROU  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)
BORENSTE 72 PR D5 1559         BORENSTEIN,DANBURG,KALBFLEISCH++ (BNL,MICH) I
KIRSCH   72 NP B40 349         SCHMIDT+CHANG,HEMINGWAY(BRAN,UMD,SYRA,TUFT) I

                               PAPERS NOT REFERRED TO IN DATA CARDS

SHAFER   66 PR 142 883         BUTTON-SHAFER,LINDSEY,MURRAY,SMITH    (LRL) JP
    A SPIN-PARITY DETERMINATION.

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Ξ(1630)

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                21  XI*1/2(1630, JP=     ) I=1/2

                THIS EFFECT NEEDS CONFIRMATION.
                THIS IS A 3- OR 4-STANDARD-DEVIATION BUMP SEEN IN ONE
                CHANNEL IN ONE EXPERIMENT. BARTSCH 69 SEE A SMALL,BROAD
                ENHANCEMENT NEAR 1650 MEV - IT IS NOT CLEAR THAT IT IS
                THE SAME PHENOMENON AS BMST 70, WHO FIND CS=3.6+-1.6
                MICROBARNS AT 2.87 GEV/C INCIDENT K- MOMENTUM.
    BORENSTEIN 72 SEE NO EFFECT IN THIS REGION. THEY FIND
    CR <  2 MUB AT 2.18.
    ROSS 72 ARGUE THAT THE EFFECT THEY SEE IS NOT THE SAME AS THAT SEEN
    BY BMST 70. ROSS 72 FIND CS= 2+-1 MICROBARNS AT 3.3 GEV/C

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                21  XI*1/2(1630) MASS (MEV)

M       40 1635.      10.            BMST      70 HBC   0 INTO  XI- PI+     7/70
M       29 1606.       6.            ROSS      72 HBC   0 K-P AT 3.1-3.7    3/72
M          . . . . . . . . . .
M   AVG    1613.7     12.8    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.5)

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                21  XI*1/2(1630) WIDTH (MEV)

W       40   57.      18.            BMST      70 HBC   0 K-P AT 2.87
W            21.       7.            ROSS      72 HBC   0 XI-PI+ K*0(890)   3/72
W          . . . . . . . . . .
W   AVG      25.7     12.2    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)

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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.

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                              REFERENCES FOR XI*1/2(1630)

BMST     70 DUKE 317          BRANDEIS+MARYLAND+SYRACUSE+TUFTS COLLABOR.
BORENSTE 72 PR D5 1559        BORENSTEIN,DANBURG,KALBFLEISCH++ (BNL,MICH) I
ROSS     72 PL 38B 177        ,BURAN,LLOYD,MULVEY,RADOJICIC           (OXF) I

                              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 1                               (2.    )

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Ξ(1820)

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                50  XI*1/2(1820, JP=     ) I=1/2

                AS THE ACCOMPANYING IDEOGRAMS ILLUSTRATE, THE SITUATION
                IS CONFUSED.  UNTIL SOME FUTURE CLARIFICATION, WE LIST
                UNDER XI(1820) EVERYTHING REPORTED IN THE MASS RANGE
                1750-1875 MEV.  WHEN BRANCHING RATIOS ARE REPORTED, WE
    QUOTE THEM, BUT ONLY THE MOST QUALITATIVE CONCLUSIONS ARE JUSTIFIED.
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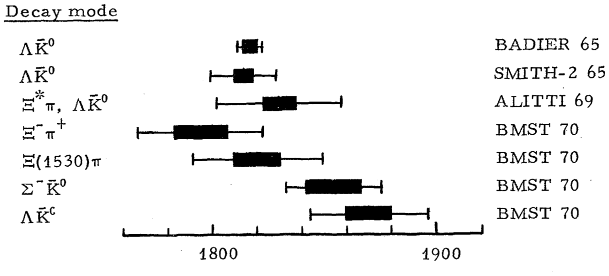
Ξ(1820)

Masses and widths of reported enhancements in the Ξ(1820) region (solid rectangles indicate error on mass).



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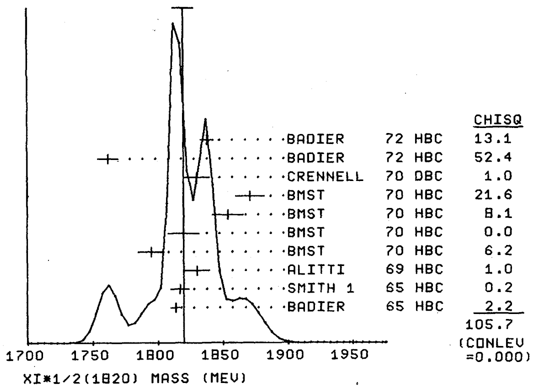
                50  XI*1/2(1820) MASS (MEV)

M         (1770.0)                       HALSTEINS 63 FBC  -0 K-FR 3.5 GEV/C
M       30 1814.0      4.0               BADIER    65 HBC   0 LAMBDA KBAR
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       65 1795.      10.                BMST      70 HBC   0 XI-PI+ (2.9 K-P)  7/70
M       55 1820.      12.                BMST      70 HBC     XI(1530) PI       7/70
M       35 1854.      12.                BMST      70 HBC  -  SIGMA- KOBAR      7/70
M       65 1871.      11.                BMST      70 HBC   0 LAMBDA  KOBAR     7/70
M       25 1830.0     10.0               CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C   10/70
M  B    28 1762.0      8.0               BADIER    72 HBC     XI PI,XI2PI,K Y  10/71
M  B    38 1838.0      5.0               BADIER    72 HBC     XI PI,XI2PI,K Y  10/71
M  B    BADIER 71 ADDS ALL CHANNELS AND DIVIDES PEAK IN LOWER AND HIGHER M
M          . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 3.4)
                         (SEE IDEOGRAM BELOW )
```



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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 KBAR
W           30.0      7.0                SMITH 2   65 HBC  -0
W           55.0     40.0      20.0      ALITTI    69 HBC  -  LAM, SIG KBAR     9/69
W       65  99.      31.                 BMST      70 HBC     XI-PI+ (2.9 K-P)  7/70
W       55  82.      42.                 BMST      70 HBC     XI(1530) PI       7/70
W       35  56.      14.                 BMST      70 HBC  -  SIGMA- KOBAR      7/70
W       65  58.      39.                 BMST      70 HBC   0 LAMBDA  KOBAR     7/70
W          103.0     38.0      24.0      CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C   10/70
W  B        51.0     13.0                BADIER    72 HBC     LOWER MASS       10/71
W  B        58.0     13.0                BADIER    72 HBC     HIGHER MASS      10/71
W                 SEE THE NOTES ACCOMPANYING THE MASSES QUOTED
W          . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)
                         (SEE IDEOGRAM BELOW )
```

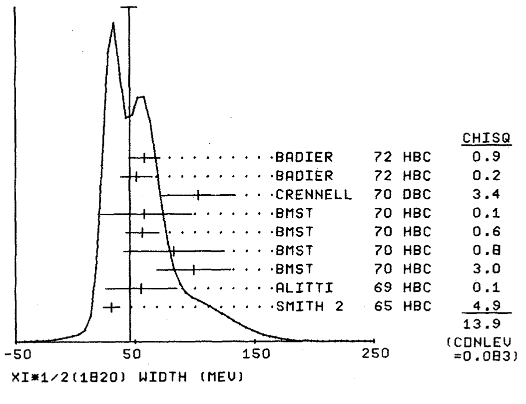

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                50  XI*1/2(1820) PARTIAL DECAY MODES

                                                            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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Data Card Listings

For notation, see key at front of Listings.

Baryons

Ξ(1820), Ξ(1940), Ξ(2030)

```
                      50  XI*1/2(1820) BRANCHING RATIOS

R1     XI*1/2(1820) INTO (LAMBDA KBAR)/TOTAL                  (P1)
R1             0.3       0.15              ALITTI     69 HBC  -                     9/69

R2     XI*1/2(1820) INTO (XI PI)/TOTAL                        (P2)
R2             0.1       0.1               ALITTI     69 HBC  -                     9/69

R3     XI*1/2(1820) INTO (SIGMA KBAR)/TOTAL                   (P3)
R3            (0.02) OR LESS               TRIPP      67 RVUE                       8/67
R3             0.3       0.15              ALITTI     69 HBC  -                     9/69

R4     XI*1/2(1820) INTO (XI*1/2(1530) PI)/TOTAL              (P4)
R4             0.3       0.15              ALITTI     69 HBC  -                     9/69
R4            (0.25) OR LESS               DAUBER     69 HBC     K-P 2.7 BEV/C      9/69

R5     XI*1/2(1820) INTO (XI PI)/(LAMBDA KBAR)                (P2)/(P1)
R5             0.20      0.20              BADIER     65 HBC                        7/66

R6     XI*1/2(1820) INTO (XI*(1530) PI)/(LAM KBAR)            (P4)/(P1)
R6             0.26      0.13              SMITH 1    65 HBC

R7     XI*1/2(1820) INTO (XI PI PI)/(LAMBDA KBAR)             (P5)/(P1)
R7            (0.1)  OR MORE               SMITH 1    65 HBC

R8     XI*1/2(1820) INTO (XI PI)/(XI*1/2(1530) PI)            (P2)/(P4)
R8             1.5       0.6       0.4     APSELL     70 HBC   0                    6/70

R9     XI*1/2(1820) INTO (XI PI PI)/(XI*1/2(1530) PI)         (P5)/(P4)
R9             0.3       0.5               APSELL     70 HBC   0                    6/70

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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
BMST     70 DUKE 317             BRANDEIS+MARYLAND+SYRACUSE+TUFTS COLLABOR.
CRENNELL 70 PR 1D 847            +KARSHON, LAI, ONEALL, SCARR, SCHUMANN(BNL)
BADIER   72 NP B37 429           +BARRELET,CHARLTON,VIDEAU              (EPOL)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

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 BMST  70.

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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.  THE SITUATION IS PERHAPS NOT
QUITE SO UNCLEAR AS IS THE CASE FOR THE XI(1820).

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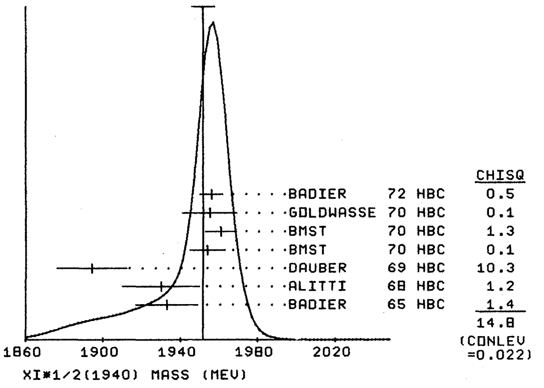
                      52  XI*1/2(1940) MASS (MEV)

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       110 1954.        9.              BMST      70 HBC   0 XI-PI+ (2.9 K-P)    7/70
M        40 1961.        8.              BMST      70 HBC     XI(1530) PI         7/70
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               . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)
                     (SEE IDEOGRAM BELOW )
```



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                      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    110  129.       30.               BMST      70 HBC   0 XI-PI+ (2.9 K-P)    7/70
W     40   42.       35.               BMST      70 HBC     XI(1530) PI         7/70
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            . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.8)
                     (SEE IDEOGRAM BELOW )
```

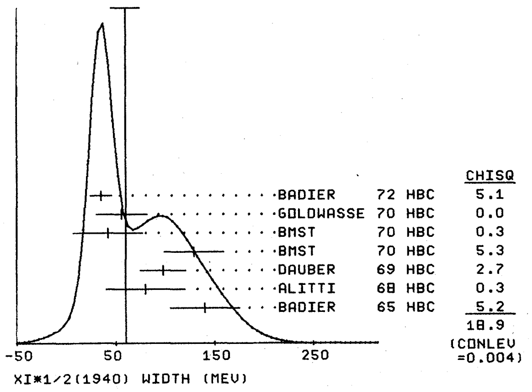

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                      52  XI*1/2(1940) PARTIAL DECAY MODES

                                                                  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

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                      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

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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
BMST     70 DUKE 317             BRANDEIS+MARYLAND+SYRACUSE+TUFTS COLLABOR.
GOLDWASS 70 PR 1D 1960           E L GOLDWASSER, P F SCHULTZ       (ILLINOIS)
BADIER   72 NP B37,429           +BARRELET,CHARLTON,VIDEAU              (EPOL)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

APSELL   69 PRL 23 884           +       (BRANDEIS, MARYLAND, SYRACUSE, TUFTS)
    SUPERSEDED BY BMST  70.

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Ξ(2030)

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68  XI*1/2(2030, JP=    ) I=1/2

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                      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 2058.0      17.0             BARTSCH    69 HBC     K-P 10GEV/C         9/69
M              . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

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                      68  XI*1/2(2030) WIDTH (MEV)

W             45.0      40.0      20.0   ALITTI     69 HBC  -                      9/69
W             57.0      30.0             BARTSCH    69 HBC                         9/69
W              . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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Baryons
Ξ(2030), Ξ(2250), Ξ(2500), Ω^-

Data Card Listings
For notation, see key at front of Listings.

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                    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 LAMBDA (OR SIGMA) KBAR PI       1115+ 497+ 139

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                    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

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  -                    9/69

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  -                    9/69

R4     XI*1/2(2030) INTO (XI* PI)/(MODES P1 THRU P4)    (P4)/(P1+P2+P3+P4)
R4            (0.15) OR LESS          ALITTI    69 HBC  - 1 STD DEV LIMIT    9/69

R5     XI*1/2(2030) INTO LAMBDA (OR SIGMA) KBAR PI      (P5)
R5            SEEN                    BARTSCH   69 HBC                       9/69

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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)

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Ξ(2250)

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                    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.

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                    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)

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                    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

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                    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 1D 1960         E L GOLDWASSER, P F SCHULTZ       (ILLINOIS)

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Ξ(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           . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 3.1)

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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           . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

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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)

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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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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) or (+-0) refer to the sign of the pions into which the K_L decays.

$\Gamma_{K^+_{\ell 3}} = \Gamma_{K^+_{e3}} + \Gamma_{K^+_{\mu 3}}$	$= (6.542 \pm .083) \times 10^6\ \mathrm{sec}^{-1}$	
$\Gamma_{K^+_{\mu 3}} / \Gamma_{K^+_{e3}}$	$= 0.668 \pm .024$	S=2.2
$\Gamma_{K^+_{\tau}} / \Gamma_{K^+_{\tau'}}$	= *3.223 ± .090*	
$\Gamma_{K^0_{\ell 3}} = \Gamma_{K^0_{e3}} + \Gamma_{K^0_{\mu 3}}$	$= (12.68 \pm .16) \times 10^6\ \mathrm{sec}^{-1}$	S=1.1
$\Gamma_{K^0_{\mu 3}} / \Gamma_{K^0_{e3}}$	$= 0.694 \pm .022$	
$\Gamma_{K^0(000)} / \Gamma_{K^0(+-0)}$	$= 1.711 \pm .081$	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

$\Gamma_{K^0_{\ell 3}} / 2\Gamma_{K^+_{\ell 3}} = 1.012$, a phase-space factor,[2] and

$$\Gamma_{K^0_{\mu 3}} / \Gamma_{K^0_{e3}} = \Gamma_{K^+_{\mu 3}} / \Gamma_{K^+_{e3}} .$$

From Table I,

$$\Gamma_{K^0_{\ell 3}} / 2\Gamma_{K^+_{\ell 3}} = 0.969 \pm .017$$

and

$$\frac{\Gamma_{K^0_{\mu 3}}}{\Gamma_{K^0_{e3}}} \left[\frac{\Gamma_{K^+_{\mu 3}}}{\Gamma_{K^+_{e3}}}\right]^{-1} = 1.039 \pm .050 .$$

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 listing 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 compilation. 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
$\phi_1(000)$ =	1.489	1.489	1.444
$\phi_2(+-0)$ =	1.221	1.294	1.279
$\phi_3(++-)$ =	1.000	1.000	1.000
$\phi_4(+00)$ =	1.247	1.183	1.147

For convenience, we repeat the slope parameters tabulated in the Stable Particle Table. They are as follows:

$g_{K_\tau^+} = -0.214 \pm 0.005$ S=1.7

$g_{K_\tau^-} = -0.214 \pm 0.007$ S=2.7

$\overline{g}_{K_\tau^\pm} = -0.214 \pm 0.004$

$g_{K_{\tau'}^+} = 0.523 \pm 0.023$ S=1.4

$g_{K^0\,(+-0)} = 0.604 \pm 0.023$ S=2.7

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 the two and use this value in Test 4.

We use the CNUDP factors and the rates and slopes reported here to compute the five test quantities which the $\Delta I = 1/2$ rule predicts to be zero. The results are:

Test 1 = 0.010 ± 0.048
Test 2 = -0.076 ± 0.026
Test 3 = 0.190 ± 0.025
Test 4 = 0.048 ± 0.012
Test 5 = 0.128 ± 0.026

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

A. SU(3) CLASSIFICATION OF BARYON RESONANCES

There are a few multiplets that have been studied and we report here the results.

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 62 and OKUBO 62 independently. In addition, for the isospin-0 vector mesons (ω and ϕ) an additional symmetry-breaking interaction had to be introduced (SAKURAI 62) 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†	(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

$$\Gamma \propto \frac{|T|^2 R_2}{M_R}, \tag{5}$$

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 $1/M_R$ (see FEYNMAN 62).

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 factor M_R, cancelling the $1/M_R$. We are then left with

$$\Gamma = \frac{|T|^2 k}{M_R} M_N, \quad \text{for baryons} \qquad (5')$$

$$= \frac{|T|^2 k}{M_R^2} M_N^2, \quad \text{for mesons} \qquad (5'')$$

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

$$\left.\begin{array}{l}\text{Decuplet}\\ \text{Singlet}\end{array}\right\} \Gamma = (cg)^2 B_\ell(k) \frac{M_N}{M_R} k \qquad (6)$$

$$\text{Octet} \quad \Gamma = (c_D g_D + c_F g_F)^2 B_\ell(k) \frac{M_N}{M_R} k \qquad (7)$$

$$\begin{array}{l}\text{Octet-}\\ \text{Singlet}\\ \text{mixing}\end{array} \left\{ \begin{array}{l} G_8 = \Lambda \cos\theta - \Lambda' \sin\theta \\ G_1 = \Lambda \sin\theta + \Lambda' \cos\theta \end{array} \right. \qquad (8)$$

$$\text{with} \quad \begin{array}{l} G_8 = c_D g_D + c_F g_F \\ G_1 = c_1 g_1 . \end{array} \qquad (9)$$

Here c_i are the SU(3) coefficients with the sign convention adopted in this article [see note preceding the table of SU(3) isoscalar 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, g_i are the relevant 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) a sum rule has been derived by BECCHI 64 and by GUPTA 64 independently. It 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 D) 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 69 convention, see Fig. 2 in the text) and the sign 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, among others, in TRIPP 68 and 69, LEVI SETTI 69, SAMIOS 70 and PLANE 70. The most recent fits were made by BARBARO-GALTIERI 72.

In fitting the data a choice for B_ℓ has to be made. PLANE 70 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-WEISSKOPF 52. Usually r is taken to be 1 fermi (TRIPP 68).

(b) The form $B_\ell = k^{2\ell}$.

However, for their final results they used form (b). A discussion of the differences among these two forms can be found in BARBARO-GALTIERI 71. It turns out that 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 isospin-0 member of the octet, $\Lambda(1690)$, the mixing angles obtained in the two cases are

$$\theta_a = (-16.1 {}^{+1.4}_{-1.3})^\circ, \quad \theta_b = (-27.5 {}^{+3.6}_{-3.4})^\circ,$$

in disagreement by a few standard deviations. It turns out that if a radius of interaction of r = 0.15 fermi is used for form (a), the two values of θ agree. This value of r does not fit resonance shapes when used in the Breit-Wigner resonant form.

Table I is a summary of the fits made by BARBARO-GALTIERI 72 using the barrier factor form (b) and exact SU(3). A few comments follow.

$\frac{1}{2}^-$ - Nonet (Baryon - Eta Resonances)

For this nonet Eq. (7) was multiplied by the factor

$$\left[\frac{M_R - M_B}{\bar{M}_R - \bar{M}_B}\right]^2 ,$$

where M_B is the decay baryon and $\bar{M}_R - \bar{M}_B$ = 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 axial vector current remains an octet in presence of symmetry breaking) and it was advocated by Graham et al. (GRAHAM 67). For the $1/2^-$ nonet it has been used in this form first by Gell-Mann et al. (GELL-MANN 68).

$\frac{3}{2}^+$ Decuplet

The agreement among the coupling constants obtained for the four rates in this decuplet is very bad. The fit made using form (b) for B_ℓ has χ^2=50 for 3 Degrees of Freedom; the one made with form (a) for B_ℓ has χ^2=24/3DF. The broken SU(3) relation (11), however, is very well satisfied.

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[†] 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.

Footnotes and References

[†] 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). For the baryon formula see A. Barbaro-Galtieri, Phenomenology of Resonances and Particle Supermultiplets. UCRL-17054 (1966).

[‡] This is an updated version of the fits by Flaminio et al., BNL report 14572.

A. Barbaro-Galtieri, Lawrence Berkeley Laboratory LBL-555, lectures given at the 1971 Erice School on Subnuclear Physics (to be published by Academic Press).

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 results of fits made by BARBARO-GALTIERI 72 to all the measured two-body decay rates of each multiplet.

J^P	Octet members[a]				Singlet	θ(deg)[b]	α
$1/2^-$	N'(1535)	Λ(1670)	Σ(1750)	[Ξ(1825)]	Λ(1405)	8±3	1.2±.1
$3/2^-$	N(1520)	Λ(1690)	Σ(1670)	[Ξ(1815)]	Λ(1520)	-23±4	.34±.09
$5/2^-$	N(1670)	Λ(1830)	Σ(1765)				1.13±.05
$5/2^+$	N(1688)	Λ(1815)	Σ(1915)				.62±.04
	Decuplet members				g_{10}		
$3/2^+$	Δ(1236)	Σ(1385)	Ξ(1530)	Ω^-		1.78 - 2.29	χ^2=50/3DF
$7/2^+$	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 $3/2^-$ mixing angle.

A. Barbaro-Galtieri, Lawrence Berkeley Laboratory LBL-1366. To be published in Proceedings of the 16th International Conference on High Energy Physics, Chicago-Batavia (1972).

C. Becchi, E. Eberle, and G. Morpurgo, Phys. Rev. 136B, 808 (1964).

J. M. Blatt and V. F. Weisskopf, Theoretical Nuclear Physics, Wiley, New York, 1952.

R. P. Feynman, Theory of Fundamental Processes, W. A. Benjamin, Inc., New York, 1962.

M. Gell-Mann, Phys. Rev. 125, 1067 (1962).

M. Gell-Mann, R. Oakes, and B. Renner, Phys. Rev. 175, 2195 (1968).

R. Graham, S. Pakvasa, and K. Raman, Phys. Rev. 163, 1774 (1967).

V. Gupta and V. Singh, Phys. Rev. 135B, 1442 (1964).

R. Levi Setti, in Proceedings of the Lund International Conference on Elementary Particles (1969).

S. Okubo, Prog. Theoret. Phys. (Kyoto) 27, 949 (1962).

D. E. Plane et al., Nuclear Physics B22, 93 (1970). Also J. Meyer and D. E. Plane, Nuclear Phys. B25, 428 (1971).

J. J. Sakurai, Phys. Rev. Letters 9, 472 (1962).

N. P. Samios, in Proceedings of the 15th International Conference on High Energy Physics, Kiev, p. 187 (1970).

R. D. Tripp, in Proceedings of the 14th International Conference on High Energy Physics, Vienna 1968, p. 173.

R. D. Tripp, in Proceedings of the 3rd Hawaiian Topical Conference on Particle Physics; UCRL-19361 (1969).

Appendix III
TEST OF ΔI=1/2 RULE FOR HYPERON DECAYS

O. E. Overseth
University of Michigan

1. Nonleptonic Decay Amplitudes

In this edition we are adopting a new convention for the amplitudes A and B. Some theorists have suggested that dimensionless amplitudes are more useful to them than the ones appearing in the literature. Berge (1966) used a convention, which we adopted last year, with A and B in units of $\sec^{-1/2}$. Samios (1965) used a convention which gave A and B in units of $(\text{MeV-sec})^{-1/2}$. Following is the convention suggested by Jackson (1973), which gives dimensionless A and B, which we will adopt in this edition.

The effective Lagrangian density for nonleptonic hyperon decays ($B_1 \rightarrow B_2 + \pi$) can be written

$$\mathcal{L}_{\text{eff}} = G\mu_c^2 [\bar{\psi}_2 (A + B\gamma_5)\psi_1]\phi_\pi ,$$

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

$$\mathcal{M} = G\mu_c^2 [\bar{u}(p)(A + B\gamma_5)u(P)] ,$$

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, $\bar{u}_i u_i = 2m_i$, 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 Section IV H shows that the amplitudes s and p defined there are proportional to A and B:

$$\frac{p}{s} = \left(\frac{E-m}{E+m}\right)\frac{B}{A} = \sqrt{\frac{(M-m)^2 - \mu^2}{(M+m)^2 - \mu^2}}\;\frac{B}{A} .$$

Here μ is the mass of the pion entering the decay. The parameters α, β, γ can therefore be expressed in terms of A and B, rather than s and p, if desired.

The decay rate for $B_1 \rightarrow B_2 + \pi$ 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.s. momentum of the decay products. For reference, the dimensionless constant in this expression has the value $(G^2 \mu_c^{\ 4}/8\pi) = 1.9488 \times 10^{-15}$.

To convert numbers for A and B of Table I, Appendix III, April 1972 edition to the new dimensionless numbers, multiply old values by $0.98124 \times 10^{-5} \mathrm{sec}^{1/2}$. This is the value of

$$\frac{\sqrt{\hbar}\ 10^5}{G\mu_c^{\ 2}\sqrt{\mu_c}} = \sqrt{\frac{65.822}{0.13958}} \left(\frac{0.93826}{0.13958}\right)^2 \times 10^{-13} \times 10^5 \times 10^5 \mathrm{sec}^{1/2}.$$

$$A_{\mathrm{new}} = 0.98124\ A_{\mathrm{old}} \times 10^{-5} \mathrm{sec}^{1/2}$$

$$B_{\mathrm{new}} = 0.98124\ B_{\mathrm{old}} \times 10^{-5}\ \mathrm{sec}^{1/2}.$$

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 and $\beta = 0$. 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	$\rightarrow m + \mu$	A	B	C_{AB}
Λ^0_-	$\rightarrow p + \pi^-$	1.50±0.01	10.28±0.25	-0.264
Σ^+_+	$\rightarrow n + \pi^+$	0.06±0.02	19.04±0.16	0.003
Σ^+_0	$\rightarrow p + \pi^0$	1.46±0.06	-12.22±0.70	0.945
Σ^-_-	$\rightarrow n + \pi^-$	1.93±0.01	-0.65±0.08	-0.030
Ξ^0_0	$\rightarrow \Lambda + \pi^0$	1.54±0.03	-5.12±1.24	0.362
Ξ^0_0	$\rightarrow \Lambda + \pi^-$	2.03±0.02	-6.86±0.52	0.207

2. Tests of the ΔI=1/2 Rule

(a) Λ Decay

For Λ decay the ΔI = 1/2 rule predicts that $\Gamma_0/\Gamma_- = 0.50$ and $\alpha_0 = \alpha_-$. In order to determine the magnitude of possible ΔI = 3/2 amplitudes present we write the linear expressions [Overseth and Pakvasa (1969)] for the ΔI = 3/2 S- and P-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

$$\Delta\alpha = -1.54(S_3/S_1) + 1.61(P_3/P_1),$$
$$\Delta\Gamma = 1.84(S_3/S_1) + 0.26(P_3/P_1).$$

Here the ΔI = 3/2 amplitudes are expressed relative to the ΔI = 1/2 amplitudes. The numerical values of the coefficients depend on the ratio P/S. The uncertainties in the coefficients are small compared to the uncertainties in $\Delta\alpha$ and $\Delta\Gamma$. Final-state π-N interactions have been included in these relations but have a very small effect. From the Stable Particle Table,

$$\Delta\alpha = 0.006 \pm 0.066, \quad \Delta\Gamma = 0.058 \pm 0.012,$$

and hence

$$(S_3/S_1) = 0.027 \pm 0.008$$

and

$$(P_3/P_1) = 0.030 \pm 0.037.$$

The possible 3% ΔI = 3/2 S-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 [Belavin and Narodetsky (1968), and Intemann (1973)], 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 ΔI = 1/2 rule is valid, $\Gamma_0(\Xi^0)/\Gamma_-(\Xi^-) = 0.50$ and $\alpha_0 = \alpha_-$. For this case the expressions linear in ΔI=3/2 S- and P-wave amplitudes are [Overseth and Pakvasa (1969)]

$$\Delta\alpha = 1.37(S_3/S_1) - 1.37(P_3/P_1),$$
$$\Delta\Gamma = -1.44(S_3/S_1) - 0.06(P_3/P_1).$$

From the Stable Particle Table,

$$\Delta\alpha = -0.040 \pm 0.234, \quad \Delta\Gamma = 0.061 \pm 0.025,$$

and we find

$$(S_3/S_1) = -0.042 \pm 0.018$$

and

$$(P_3/P_1) = -0.013 \pm 0.164.$$

(c) Σ Decay

The traditional test of the ΔI = 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 ΔI ≥ 3/2 amplitudes in Σ decay analysis, the "Σ triangle" relationship becomes

$$\sqrt{2}\,A_0 + A_+ - A_- = -\,3\sqrt{\frac{2}{5}}\,A_3 + \frac{2}{\sqrt{15}}\,A_5,$$

where A_3, A_5 are ΔI = 3/2, 5/2 amplitudes, respectively. There is a similar equation for the B amplitudes. From Table I,

$$\sqrt{2}A_0 + A_+ - A_- = 0.19 \pm 0.11$$
$$\text{and}\ \sqrt{2}B_0 + B_+ - B_- = 2.41 \pm 1.23.$$

If we neglect the ΔI = 5/2 amplitudes and assume all amplitudes to be real we can solve for possible ΔI= 3/2 amplitudes. The result is

$$\frac{A_3}{A_-} = -\,0.052 \pm 0.029$$

and

$$\frac{B_3}{B_+} = -\,0.067 \pm 0.033\,.$$

Thus for hyperon decay, present experimental data limit ΔI = 3/2 amplitudes to less than about 5%.

3. The Lee-Sugawara Relation

From Table I the Lee-Sugawara [Lee (1964) and Sugawara (1964)] relation $\sqrt{3}\ \Sigma_0^+ + \Lambda_- - 2\,\Xi_-^- = 0$ is satisfied to -0.03 ± 0.15 for the A amplitudes, and to 2.83 ± 2.50 for the B amplitudes.

References

A. A. Belavin and I. M. Narodetsky, Yadern. Fiz. 8, 978 (1968) [Soviet J. Nucl. Phys. 8, 568 (1968)]

J. P. Berge, in Proceedings of the 13th International Conference on High-Energy Physics, Berkeley, (1966) (University of California Press, Berkeley, 1967), p. 46.

G. W. Intemann, Bull. of Am. Phys. Soc. 18, 26 (1973).

J. D. Jackson, private communication (1973).

B. W. Lee, Phys. Rev. Lett. 12, 83 (1964).

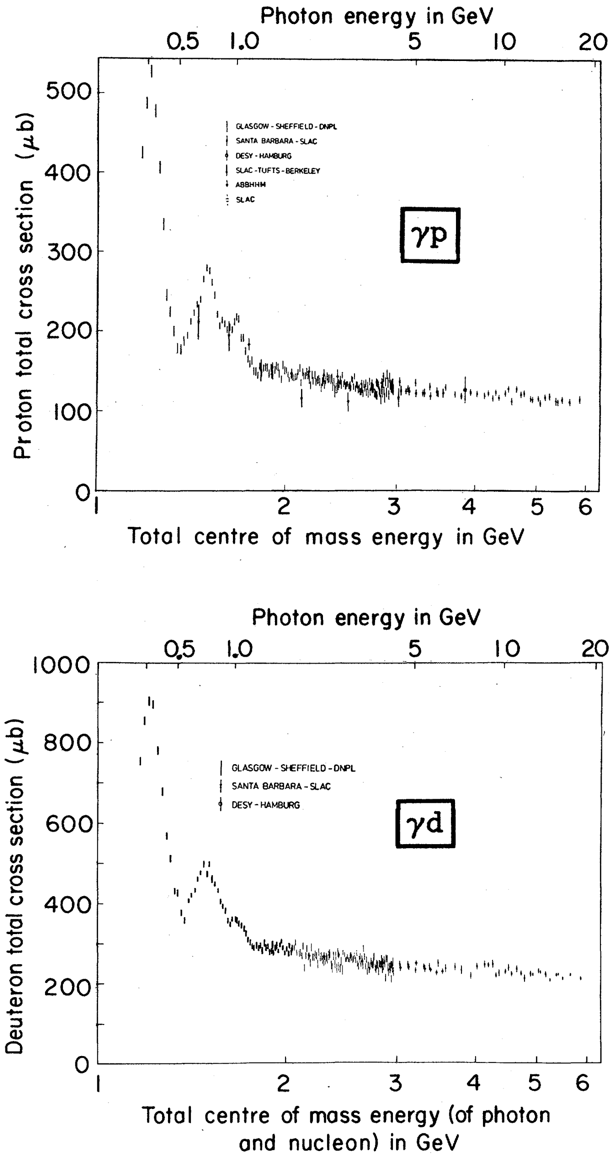
O. E. Overseth and S. Pakvasa, Phys. Rev. 184, 1663 (1969). The expression for Γ_0/Γ_- for Λ decay should read

$$\frac{\Gamma^0}{\Gamma^-} \approx \frac{1}{2}\left\{1 + 3\sqrt{2}\right.$$
$$\left.\times\left(\frac{[S_{11}S_{33}\cos(\delta_1-\delta_3)+P_{11}P_{33}\cos(\delta_{11}-\delta_{31})]}{S_{11}^2 + P_{11}^2}\right)\right\}.$$

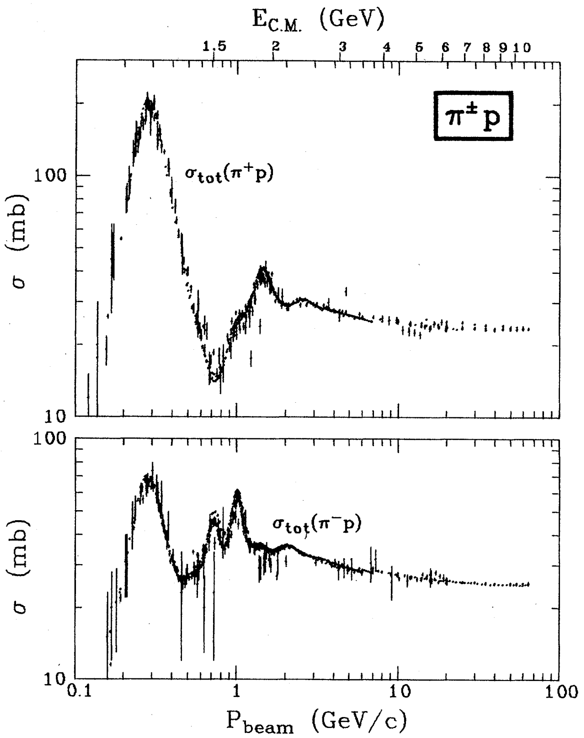
N. P. Samios, International Conference on Weak Interactions, Argonne (1965), p. 189.

H. Sugawara, Prog. Theor. Phys. 31, 213 (1964).

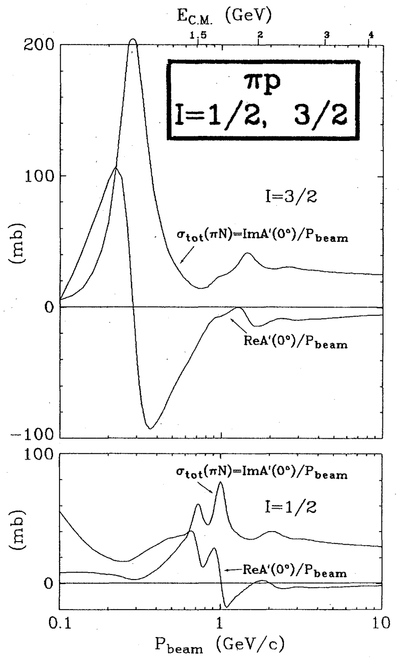
CROSS SECTION PLOTS



$\sigma_{tot}(\gamma p)$ and $\sigma_{tot}(\gamma d)$ as compiled by G. M. Lewis, Glasgow.



πN total cross section data from the compilation of C. Lovelace, et al. (see Sec. VI C of the text).



A smooth interpolation of the πN total cross sections for I=3/2 and I=1/2, and the corresponding real parts of the forward amplitudes as calculated from dispersion relations by G. Höhler and H. P. Jakob (private communication). The normalization of the curves for each value of I is such that the sum of their squares divided by 19.6 gives $d\sigma/dt$ at 0° in mb/(GeV/c)^2.